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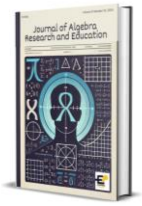

Error Analysis of Students in Solving Algebraic Expression Problems Using the Newman Procedure

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Abstract

This research aims to determine the forms of errors made by class VIII students of SMPN 3 Rambah Hilir in solving algebraic operations material questions based on Newman's procedure. This research employs a descriptive qualitative approach. The subjects in this research were class VIII SMPN 3 Rambah Hilir. The research instrument uses tests and interviews. Based on the results of data analysis, it was concluded that students made (1) errors in reading the questions of 100% in the form of not knowing the meaning of the questions; (2) errors in understanding the questions of 26,7% in the form of not knowing what to look for; (3) mistakes transforming questions amounted to 50,0% in the form of not being able to determine the mathematical operations and formulas used to solve the problem; (4)errors in process skills amounting to 64,4% in the form of errors in calculations with; (5) errors in writing the final answer amounting to 68,9% consist of errors in writing the final answer and not making a conclusion.

Keywords: Algebraic forms; Error analysis; Newman procedures.

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1. Introduction

Mathematics is an indispensable component of modern education, playing a crucial role in equipping students with logical reasoning, analytical thinking, and problem-solving skills that are essential in everyday life and across various professional domains. As Susanto (as cited in

Surya, 2019) asserts, mathematics not only facilitates the resolution of real-world problems but also significantly contributes to the advancement of education by fostering critical intellectual abilities. Despite its importance, the process of teaching and learning mathematics does not always yield optimal results for every student. A considerable number of students encounter difficulties when engaging with mathematical content, particularly in solving complex problems. These difficulties frequently manifest as errors that hinder academic progress and obscure a clear understanding of mathematical concepts (Hidayati et al., 2021).

Identifying and understanding the root causes of such errors is fundamental to enhancing instructional practices and improving student outcomes. According to Ayuwirdayana (2019), students' errors in mathematical problem-solving may arise from a variety of sources, including but not limited to computational mistakes, limited reasoning abilities, inappropriate application of procedures, challenges in selecting effective problem-solving strategies, misinterpretation of problem statements, restricted vocabulary, poor reading habits, and a general lack of attentiveness. These multifaceted issues reflect the complexity of mathematical cognition and underscore the need for educators to employ diagnostic approaches that can uncover the nature and origin of student errors. Without such analysis, students are at risk of developing persistent misconceptions that impede their mastery of foundational concepts and problem-solving proficiency (Rahmania et al., 2016; Yulia et al., 2017).

One such approach is error analysis, a structured method for examining the discrepancies and mistakes present in students' written responses to mathematical tasks. As emphasised by Rahmania et al. (2016), error analysis serves as a valuable tool for identifying specific learning difficulties and misconceptions, thereby allowing teachers to address these issues in a targeted and effective manner. Hidayati et al. (2021) further argue that implementing error analysis in mathematics instruction is critical for monitoring student progress, personalising learning experiences, and refining pedagogical strategies. Moreover, Syafitri (2019) highlights that the frequency and types of errors students make can provide significant insight into their level of comprehension and cognitive development in mathematics.

During my internship at SMPN 3 Rambah Hilir, it was observed that many students struggled particularly with algebraic operations, demonstrating a high incidence of errors in both symbolic manipulation and problem-solving. These observations align with findings from Wildani (2018), who employed Newman's Error Analysis (NEA) framework to investigate common mistakes in algebra and identified transformation and comprehension errors as especially prevalent. Similarly, Lampongajo et al. (2017) reported that procedural and conceptual errors were frequently encountered among students tackling algebraic problems, suggesting a widespread challenge in applying correct mathematical methods and understanding abstract algebraic principles.

To systematically analyze and categorize these errors, the Newman Error Analysis (NEA) framework, introduced by Anne Newman in 1977, remains a widely accepted and effective diagnostic tool in mathematics education (White, as cited in Surya, 2019). This framework dissects the problem-solving process into five sequential stages: reading the problem, comprehending the meaning, transforming the problem into a mathematical model, processing or performing calculations, and encoding or presenting the final answer. Errors can occur at any of these stages, and identifying the specific stage at which a breakdown occurs enables educators to design focused interventions to address the underlying issues. Recent empirical studies, including those by Smith and Johnson (2021) and Lee et al. (2022), continue to validate the relevance of NEA in contemporary educational contexts, emphasising its efficacy in diagnosing errors and guiding instructional improvement.

In conclusion, integrating a comprehensive error analysis based on Newman's procedural framework is critical for enhancing the effectiveness of mathematics instruction. Such analysis not only facilitates a deeper understanding of students' learning difficulties but also empowers educators to tailor their teaching methods to meet individual learning needs. By systematically identifying where and why students make errors, teachers can implement informed strategies that promote conceptual understanding, strengthen problem-solving skills, and ultimately improve students' academic achievement in mathematics (Brown & Davis, 2020; Zhang, 2023). As education continues to evolve, the role of analytical frameworks like NEA will remain vital in supporting data-driven teaching and fostering meaningful learning experiences for all students.

2. Methods

This study employs a qualitative research approach utilising a descriptive method to explore and analyse the types of errors students make in solving mathematical problems, specifically within the context of algebraic operations. The qualitative approach was selected due to its strength in providing in-depth, detailed insights into student behaviour, thought processes, and learning experiences, which are not easily captured through quantitative methods. This approach allows the researcher to interpret the meaning behind student actions and responses by analysing patterns in their written work and verbal explanations. The descriptive method in this study is used to systematically describe the current state of a phenomenon, namely, the types and frequencies of errors committed by students during mathematical problem-solving tasks. Rather than manipulating variables or testing hypotheses, this method focuses on capturing real conditions as they exist in the classroom. It emphasises naturalistic observation and detailed documentation of student behaviours, mistakes, and reasoning, all of which are crucial for understanding the difficulties students encounter during the learning process.

The research was conducted through direct observation and analysis of student responses to mathematics test items, supported by follow-up interviews. The aim was to present a clear and objective picture of the problem-solving processes used by students and to identify the specific points at which errors occurred. The observational process was complemented by interpretive analysis, allowing the researcher to explore how and why students arrived at incorrect answers and to conclude their understanding of mathematical concepts.

The sampling technique used in this research is purposive sampling, a non-random method where subjects are selected based on specific characteristics relevant to the research objectives. This technique was chosen to ensure that the participants involved in the study could provide meaningful and relevant data. In this case, the participants were selected based on their performance on algebraic problem-solving tasks and their representation of various types of mathematical errors. The selected students were those who displayed specific errors that aligned with the categories being studied, ensuring that the sample would offer rich data for analysis. The research was conducted with students from Class VIII at SMP Negeri 3 Rambah Hilir, focusing specifically on students in Class VIII A, which consists of a total of 30 students. The entire class was given a set of mathematics problems designed to assess their understanding of algebraic concepts and operations. Upon completion of the tasks, the students' responses were analysed and categorised according to the five error types identified in the Newman Error Analysis framework: reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors.

After categorising the student work based on these error types, the researcher selected two representative students from each error category, resulting in a total of ten students for the interview phase. These students were chosen because their written responses provided clear examples of each type of error. The interviews were conducted to gain deeper insight into the students' thought processes, including how they interpreted the problems, why they made certain decisions during problem-solving, and how they understood the mathematical concepts involved.

To collect data, this study utilised two main research instruments: mathematical problem-solving test questions and semi-structured interviews. The test questions served as the primary tool for identifying errors and assessing student performance, while the interviews allowed for a more in-depth exploration of the cognitive processes and reasoning behind each student's approach to the problems. The combination of written assessments and verbal responses provided a comprehensive understanding of student difficulties and enabled the researcher to triangulate findings across different data sources. Through this methodological approach, the study aimed to provide a detailed and systematic analysis of student errors in algebra, offering valuable insights for improving mathematics instruction and helping students overcome common learning obstacles.

3. Results and Discussion

3.1 Results

Based on the test results administered to students in Class VIII A, the data regarding the types of errors identified—categorised according to Newman's theory—are presented in Table 1. This table illustrates the distribution and frequency of each error type, providing a clearer picture of the specific difficulties encountered by students during problem-solving.

Table 1 - Description of Student Error Types Based on Newman's Theory

Type of Errors	Total Number of Errors	Percentage
Reading the questions	9	10%
Understanding the questions	24	26.7%
Transforming the questions	45	50%
Process skills	58	64.4%
Writing the final answer	62	68.9%

From Table 1, it can be seen the percentage of errors made by students in solving problems. It shows that for question number 1, the most common mistake made by students is in writing the final answer with a percentage of 76.7%. For question number 2, the most common mistakes made by students are in processing skills and writing the final answer with a percentage of 70.0%. For question number 3, the most common mistakes made by students are in processing skills with a percentage of 66.7%. Thus, the average percentage of errors commonly made by students overall is in the stage of writing the final answer, which is 68.9%. Based on the students' test results in solving algebra problems according to the types of errors in Newman's theory, 10 students out of 30 who took the test were chosen as interview subjects as follows:

Table 2 - Interview Subjects Based on Newman's Theory

Code of Students	Number	Type of Errors
CDR	3	Mistake in Reading Questions
SN	2	Mistake in Reading Questions
DN	2	Mistake in Understanding Questions
NNA	1	Mistake in Understanding Questions
ARA	2	Mistake in Question Transformation
SL	3	Mistake in Question Transformation
MA	2	Mistake in Process Skills
TR	2	Mistake in Process Skills
AMJ	2	Mistake in Writing Final Answers
ZP	1	Mistake in Writing Final Answers

This study was conducted to identify and analyse the types of errors made by students in solving problems related to algebraic operations, using the Newman Error Analysis framework. The research involved 30 students from Class VIII A at SMP Negeri 3 Rambah Hilir, whose written responses and interview results were examined in detail. The analysis focused on categorising the students' mistakes into five distinct types of errors: reading, comprehension, transformation, process skills, and encoding. The findings revealed that reading errors were present in approximately 10% of the students. These errors typically occurred when students had difficulty identifying or understanding the essential information embedded in the problem statement, even after reading the question thoroughly. Such difficulties suggest a lack of reading comprehension strategies or insufficient attention to key details in mathematical text.

Comprehension errors were found in 26.7% of the students. These errors occurred when students failed to identify or write down what was already known and what was being asked in the problem. Many of these students either omitted crucial elements or recorded them incorrectly, often due to working too quickly or under the assumption that writing out the known and unknown parts of the problem was unnecessary. This behaviour indicates a superficial understanding of the problem and a tendency to skip essential analytical steps. The most prominent issue identified was transformation errors, which were committed by 50% of the participants. Students in this category struggled to convert the given verbal problems into appropriate mathematical models or expressions. Many either misused mathematical formulas or selected incorrect operations, showing that they lacked the conceptual understanding required to interpret and translate word problems into symbolic representations.

Furthermore, process skill errors were observed in 64.4% of the students. These errors were related to mistakes in carrying out the mathematical procedures after determining the correct approach. Students often made computational errors, skipped steps, or failed to follow procedures in a logical sequence. Such issues were frequently linked to earlier transformation errors, suggesting that misunderstanding the problem structure had a cascading effect on their ability to execute accurate calculations. Finally, the most frequently occurring errors were encoding errors, found in 68.9% of the students. These errors occurred when students, despite arriving at a solution or completing most of the problem-solving process, failed to present the final answer correctly. In some cases, the answers were incorrect due to prior mistakes, while in others, students neglected to write a conclusion or communicate their final response. This pattern indicates that many students do not sufficiently review their work or recognise the importance of clearly articulating their final answers in mathematics.

3.2 Discussion

The results of this study reveal a pattern of mathematical errors that aligns closely with findings from previous research conducted in comparable educational contexts. Although reading errors were the least frequent, affecting only 10% of the sample, this is consistent with broader trends in secondary mathematics education, where such errors are typically minimal. For instance, one study involving high school students found that reading errors occurred in only 2.2% of participants, suggesting that most students can decode problem statements at a basic level. However, more substantial challenges emerge in the subsequent stages of comprehension and problem transformation, which are often the dominant sources of difficulty in mathematical problem-solving. In this study, comprehension errors were found in 26.7% of students, indicating a moderate but significant issue in interpreting or articulating the known and unknown elements of a problem. This result is comparable to that of Fatawu (2023), who reported comprehension errors as the most prevalent error type among senior high students at a rate of 45.4%, and Nur Agustiani (2021), who found a lower rate of 18.9% among university students working with sequences and series. These discrepancies may be attributed to differences in age group, mathematical topic, problem complexity, or the cognitive demands of the given tasks.

The study further highlights that transformation errors were experienced by half of the students (50%), reflecting a persistent challenge in converting verbal or contextual problem statements into appropriate mathematical expressions or models. These findings are supported by a wide range of previous studies that report transformation errors in the range of 34% to 68%, reinforcing the notion that this type of error is a major stumbling block for students learning algebra. This suggests that many students struggle to bridge the gap between language comprehension and symbolic representation a skill that requires both conceptual understanding and procedural flexibility. Furthermore, process skill errors which involve mistakes during the execution of calculations were found in 64.4% of students. This type of error frequently occurs when students attempt to solve problems without a clear plan or when they apply incorrect operations due to prior transformation mistakes. Previous research has shown similar rates, including studies where over 70% of junior high students made significant process-based errors. These errors often reflect deficiencies in procedural fluency, accuracy, and step-by-step reasoning, which are critical components of successful problem solving in mathematics.

Among all the error categories identified, encoding errors were the most prevalent, occurring in 68.9% of students. These errors occurred even after students had successfully completed most or all of the problem-solving process, suggesting a disconnect between computation and the final representation of the answer. In many cases, students either provided an incorrect final response or failed to write down the conclusion altogether. This phenomenon is consistent with the findings of Ahzan et al. (2022), who reported an even higher encoding error rate of 86.7% in a study of eighth-grade students. Furthermore, recent contingency analyses have highlighted the frequent co-occurrence of encoding and process skill errors, indicating that students who struggle with calculation steps often encounter additional difficulty in presenting their final answers accurately and completely. These interconnected errors underscore the importance of viewing the problem-solving process as a sequential system, where breakdowns in earlier stages, such as transformation and processing, can cascade into subsequent errors in encoding (Santika et al., 2025; Apriliani et al., 2025; Loska et al., 2024; Islamiyah et al., 2024).

Overall, the progression of errors observed in this study, from reading through encoding, illustrates a clear trajectory of increasing difficulty as students move through the stages of problem-solving. This pattern suggests that initial misunderstandings in reading or comprehension often go unnoticed until they manifest in more visible computational or final-answer mistakes. Notably, the transformation and encoding stages appear to serve as bottlenecks, where the majority of students falter. These findings are consistent with a growing body of educational literature emphasising the cognitive demands of algebraic word problems and the need for scaffolding support in these areas. As such, the study underscores the importance of targeted instructional interventions that address each stage of the problem-solving process. These may include structured reading strategies and vocabulary development to enhance comprehension, scaffolded exercises that support the translation of verbal problems into algebraic form, explicit instruction in procedural fluency and stepwise calculations, and techniques that encourage students to review and clearly articulate their final answers. Implementing such strategies in classroom instruction may significantly reduce student errors and enhance overall mathematical understanding and performance.

4. Conclusions

Based on the results of the study, it can be concluded that there are several types of errors made by students in solving problems related to operations on algebraic expressions based on Newman's Procedure. These include: reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors. There was a 10.0% reading error, where students failed to grasp the information contained in the problem. There was a 26.7% comprehension error, where students did not know or did not write down what was known and what was being asked in the problem. There was a 50.0% transformation error, where students could not determine the appropriate mathematical operation or formula needed to solve the problem. There was 64.4% process skill error, where students were unable to construct the necessary steps for solving the problem, were careless in calculations, did not manage their time well, and rushed through the problem. There was a 68.9% encoding error, where students failed to write the conclusion of the answer, wrote incorrect notations in their conclusions, were unable to provide accurate final answers, and were not careful in completing the problem.

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Conflict of Interest

The authors declare no conflicts of interest.

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