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The Mystery of Student Errors in Math Story Problems: A Critical Riview of Newman's Theory

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Abstract

Mathematical word problems remain one of the most challenging domains in elementary mathematics education, particularly in fraction operations. This study critically examines students' difficulties in solving fraction-based word problems through the lens of Newman's Error Analysis (NEA). Conducted among fourth-grade students at SDN Lubang Buaya 05 Pagi, East Jakarta, the research employed a qualitative descriptive design involving written tests, interviews, classroom observation, and documentation. Findings reveal persistent difficulties across Newman's five stages: reading, comprehension, transformation, process skills, and encoding. Although reading and comprehension scores were relatively high (92% and 81%), substantial difficulties emerged at the transformation (77%), process skills (59%), and encoding (40%) stages. The study argues that errors in word problems are not merely procedural but reflect deeper representational and conceptual gaps. By integrating recent international research on mathematical literacy, representation theory, and cognitive load, this paper offers a critical re-examination of Newman's framework and proposes pedagogical implications aligned with contemporary mathematics education reform

Keywords: Fraction operations, Learning difficulties, Newman's Error Analysis

1 INTRODUCTION

Mathematics education in elementary school plays an important role in developing students' logical, systematic, critical, and creative thinking skills. Mathematics is not only a core subject, but also the foundation for mastering science and technology, which influence the development of the modern world. In addition, mathematics trains students to solve everyday problems so that what they learn can be applied in real life.

However, each student has different abilities in understanding mathematical concepts. Many students still consider mathematics a difficult, intimidating, and boring subject. Low interest and motivation to learn, infrequent practice questions, and lack of repetition of material exacerbate the situation. As a result, students often feel anxious, make repeated mistakes, and experience a decline in academic achievement.

One of the most prominent difficulties is when students work on word problems, especially those involving fraction calculations. Word problems require students to read the text carefully, understand the meaning of the question, choose the correct calculation, and write the final answer correctly. Obstacles often arise when students fail to identify important information, are unable to transform sentences into mathematical form, or make mistakes in their calculations.

The results of the 2022 Programme for International Student Assessment (PISA) show that Indonesia ranks 69th in literacy and 67th in mathematics out of 81 participating countries. Although this is an improvement compared to 2018, these achievements are still considered low. Findings in the field also reinforce this data. Observations and

interviews with teachers and fourth-grade students at SDN Lubang Buaya 05 Pagi showed that students often had difficulty determining arithmetic operations, made mistakes in fraction calculations, and wrote incorrect final conclusions. To analyze these difficulties, this study uses Newman's Error Analysis or Newman's Theory. This theory covers five stages of error, namely reading error, comprehension error, transformation error, process skills error, and encoding error. Through this framework, teachers can identify students' difficulties more specifically so that they can provide interventions tailored to their needs.

Previous studies have shown that students' difficulties in word problems are very diverse. Hamdana (2022) found that students often fail in the stages of understanding the problem, transformation, and process skills. Azzahroh (2021) emphasized that the biggest mistake lies in process skills because students are not careful in their calculations. Candrasari (2020) added that internal factors, such as motivation and interest, as well as external factors, such as teacher support and learning media, greatly contribute to students' difficulties. These results show that story problems are not only related to calculations but also to aspects of understanding and learning strategies.

Unlike previous studies, this study offers something new by analyzing the difficulties of fourth-grade students in fractions using Newman's Theory. Fractions were chosen because they are still one of the concepts that students find difficult to master. Common mistakes that often arise are the inability to equalize denominators, perform calculations on mixed fractions, and write the final answer correctly.

Based on this description, this study focuses on identifying the difficulties of fourth-grade students at SDN Lubang Buaya 05 Pagi in solving fraction word problems based on Newman's Theory. Thus, this study is expected to contribute to the development of more varied, systematic, and contextual mathematics learning strategies so that students become more skilled in solving word problems correctly.

2 RESEARCH METHODS

This study uses a descriptive qualitative approach that aims to explore in depth the difficulties students face in solving math word problems, particularly those involving fraction calculations. This approach was chosen because it allows researchers to describe real conditions in the field without manipulating the variables under study.

Data analysis in this study refers to Newman's Error Analysis, which classifies student errors into five types, namely reading errors, comprehension errors, transformation errors, process skills errors, and encoding errors. Through this theory, student difficulties can be systematically identified at each stage of the story problem-solving process.

The research was conducted at SDN Lubang Buaya 05 Pagi, East Jakarta, in the odd semester of the 2024/2025 academic year, specifically from June to July 2025. The research subjects consisted of 22 fourth-grade students who had studied fractions, with 9 male students and 13 female students.

The research process was carried out in several stages, namely the planning, implementation, data analysis, and conclusion drawing stages. In the planning stage, the researcher developed instruments in the form of written tests, interview guidelines, and observation sheets. The implementation stage included administering tests, interviewing students, observing the learning process, and collecting documentation. The collected data was then analyzed based on the classification of errors according to Newman's Theory, and the results were used as the basis for drawing research conclusions.

The research data was obtained through four main techniques, namely written tests, interviews, observations, and documentation. Tests were used to identify the types of errors made by students, interviews were conducted to explore the causes of these errors, observations aimed to understand the students' thought processes when working on problems, while documentation was used as supporting data. The validity of the data was ensured through triangulation of techniques and sources, namely by comparing the results

of various data collection methods and involving teachers and students as the main sources of information.

3 RESULT AND DISCUSSION

3.1 Result

3.1.1 General Description of the Research

SDN Lubang Buaya 05 Pagi is a public elementary school that was established in 1975 and has been accredited with an A rating. The school is located at Jalan Yusufiah No. 50, Kelurahan Lubang Buaya, Kecamatan Cipayung, East Jakarta, with a land area of 1,340 m². Learning facilities are adequate, including internet access and electricity from PLN. The school is currently led by Mrs. Siti Khodijah, S.Pd., with 17 teaching and non-teaching staff and 415 students (207 boys and 208 girls) divided into 13 learning groups. In the 2024/2025 academic year, the school will implement the Merdeka Curriculum.

Fourth-grade students still face challenges in mathematics learning, particularly in fraction-related word problems. Based on Newman's Theory, the errors that arise include reading errors, understanding the questions, transformation, process skills, and writing the final answer. The contributing factors come from internal aspects (ability, motivation, and interest in learning) and external aspects (teacher learning strategies, difficult question language, and lack of contextual practice).

This school was chosen as the research location because initial observations and interviews showed that students had real difficulties in solving fraction word problems. It is hoped that the results of this study can help teachers develop varied, contextual, and interesting learning strategies so that students can better understand the concept of fractions and be able to think critically, logically, and systematically

3.1.2 Main Findings

Five types of errors were found according to Newman’s Theory indicators:

1. Reading Error: students have difficulty reading mathematical terms and symbols.
2. Comprehension Error: students fail to grasp important information.
3. Transformation Error: students are unable to transform the problem into a mathematical model.
4. Process Skill Error: students make mistakes in fraction calculations.
5. Encoding Error: students do not write down the answer as requested in the question.

3.2 Discussion

The results of the study indicate that the transformation stage and process skills are the most dominant sources of difficulty, while reading errors are relatively low. This

shows that students' basic literacy skills are quite good, but they still have difficulty converting story problems into mathematical models. These findings are in line with Santoso's (2020) study, which states that mathematical representation skills are the main obstacle in solving contextual problems.

At the problem comprehension stage, some students were unable to identify relevant information, supporting the findings of Rizkyta & Astriani (2024), who emphasized that weak mastery of prerequisite concepts affects the selection of solution strategies.

Errors in process skills indicate that many students have not mastered operations with fractions with different denominators. This condition is consistent with the results of research by Lusi & Heni (2021), which found that procedural errors remain high even though students understand the questions, due to a lack of structured practice.

The aspect of writing the final answer is also a common weakness, where students often do not write a complete conclusion. This finding supports the research by Hadaming & Wahyudi (2022), which states that encoding errors often occur because students rush and are not accustomed to checking their work.

Overall, the factors causing students' difficulties include internal factors such as low motivation, lack of accuracy, and weak mastery of concepts, as well as external factors such as learning strategies that lack variety, a lack of contextual practice questions, and

the use of media that is not yet relevant. Recommended efforts include strengthening the concept of fractions, utilizing contextual media, providing gradual practice, and presenting questions in simple and easy-to-understand language.

3.3 Table

Table 1. Percentage of Student Errors Based on Newman's Theory

Aspect	Score	Maximum Score	Percentage
Reading	608	660	92%
Comprehension	535	660	81%
Transformation	506	660	77%
Process	392	660	59%
Encoding	267	660	40%

The findings of this study reveal that students' errors in fraction word problems are not primarily rooted in basic literacy limitations, as evidenced by the high achievement in the reading stage (92%). This indicates that students are generally capable of decoding mathematical text and identifying keywords. However, reading accuracy alone does not guarantee successful problem-solving. Contemporary research emphasizes that decoding skills represent only the surface level of mathematical literacy, while deeper representational understanding determines actual success in word problem contexts (OECD, 2023).

Although comprehension performance reached 81%, students still encountered substantial difficulties in subsequent stages. This suggests that comprehension in this context may reflect literal understanding rather than relational or inferential comprehension. Boonen et al. (2020) argue that effective word problem solving requires students to construct mental models that integrate quantitative relationships, not merely restate textual information. The gap between surface comprehension and relational reasoning becomes visible in the transformation stage.

The transformation stage (77%) represents a critical cognitive bottleneck. Students struggle to convert verbal narratives into mathematical representations. According to Duval's (2021) theory of semiotic representation, mathematical understanding requires coordination between different representational registers—verbal, symbolic, and graphical. Students in this study appear capable of operating within one register but encounter difficulty when translating across registers, particularly from linguistic form to algebraic or fractional notation.

This representational weakness is consistent with research by Verschaffel et al. (2020), who found that students often rely on superficial keyword strategies rather than constructing meaningful mathematical models. In fraction problems, keywords such as "remaining" or "used" may prompt subtraction mechanically, without deeper conceptual analysis. Such strategy reliance increases the likelihood of inappropriate transformation when problem structures vary.

The most significant decline appears in the process skills stage (59%), indicating persistent procedural errors in fraction operations. This confirms findings by Rittle-Johnson et al. (2021), who emphasize that procedural fluency without conceptual understanding leads to fragile knowledge structures. Students may memorize steps for equalizing denominators but fail to apply them flexibly in contextualized problems.

Fractions are widely recognized as cognitively demanding due to their dual-component structure (numerator and denominator) and non-intuitive magnitude properties (Siegler et al., 2021). Many students treat fractions as two separate whole numbers rather than relational quantities. Hansen et al. (2022) report that misconceptions about fraction magnitude and equivalence significantly predict procedural errors, particularly when denominators differ.

Cognitive Load Theory provides further explanatory power. Word problems impose intrinsic load (fraction reasoning complexity) and extraneous load (text processing demands). Sweller et al. (2021) argue that when working memory is overloaded, students default to procedural shortcuts. The simultaneous requirement to interpret text, construct models, and perform fraction calculations likely exceeded students' working memory capacity, contributing to high transformation and process errors.

Encoding errors (40%) represent the final breakdown in problem-solving. Even when calculations are partially correct, students often fail to articulate answers according to the question's demand. Prediger et al. (2022) emphasize that mathematical communication is integral to reasoning, not merely a reporting stage. Failure to encode final answers indicates incomplete metacognitive regulation and limited reflective verification.

Metacognition plays a crucial mediating role in this process. Stillman and Brown (2021) suggest that students who monitor their reasoning at each stage of modeling are less likely to commit transformation and encoding errors. The absence of systematic self-checking strategies in this study suggests that students rely primarily on procedural memory rather than reflective thinking.

Interestingly, the relatively high reading and comprehension scores challenge assumptions that literacy deficits are the main cause of poor mathematical performance. Instead, the data suggest that representational fluency and procedural integration are more decisive factors. This nuance refines interpretations of PISA findings, indicating that improving reading alone may not sufficiently enhance mathematical literacy outcomes.

3.4 Picture

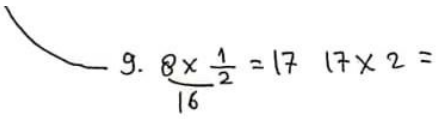

Figure 1. Example of student errors in Reading Error.

Figure 1 shows students' errors in the question reading stage (Reading Error), namely not copying information according to the text and misrecognizing mixed number symbols. These results are in line with Naila et al. (2023), who found that reading errors were only 1.65%, so it can be concluded that the main obstacle for students is not their reading ability, but rather the stage of comprehension and transformation.

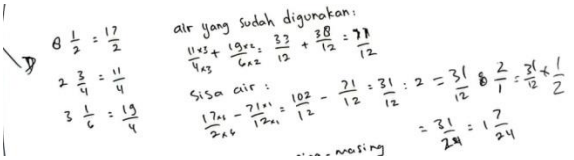

Figure 2. Example of student errors in Comprehension Error

Figure 2 shows a student's error in understanding the problem. The student wrote down the fraction of water that had been used, then calculated the remainder, but the calculation was not logical and ended with the wrong result. This shows confusion in dividing the remaining water evenly. This finding is in line with the research by Fida et al. (2021), which explains that comprehension errors are often a continuation of reading errors, even though their research did not find significant obstacles at the comprehension stage. Thus, difficulties in understanding problems are more apparent when students try to rewrite the

information from the question and determine what is actually being asked, so that failure at this stage affects the next steps in solving the problem.

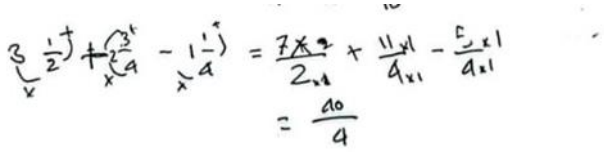

Figure 3. Examples of student errors in Transformatin Error.

Figure 3 shows student errors at the transformation stage. The students' answers show that the calculation process is not sequential. Students wrote down the mixed fraction , but were unable to convert it into a clear addition operation. The calculation was instead converted to a common fraction without the appropriate adjustments. This condition confirms that students have difficulty transforming word problems into the correct mathematical model. These results are in line with the research by Nyamik et al. (2020), which found that around 50% of students experience transformation difficulties. These errors arise because students are unable to identify the key words in the problem, are not careful in reading symbols, do not write down the information that is known or asked, and fail to determine the appropriate calculation operation. As a result, students are also unable to write down the correct conclusion. Thus, weaknesses in the transformation stage are one of the main factors that hinder students in solving mathematical word problems correctly.

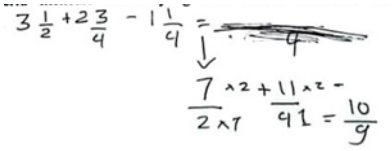

Figure 4. Example of student errors in Process Error.

Figure 4 shows student errors in the process skill stage. Students wrote mixed fractions correctly and tried to perform subtraction operations, but their calculation steps were not sequential, resulting in incorrect answers. This shows that students understood the meaning of the question and were able to transform it into a mathematical model correctly, but were still mistaken in the fraction operation procedure. This finding is in line with the research by Hamdana et al. (2022), which states that process errors were made by all research subjects. Such errors usually arise because students are not careful in following the calculation procedure. To minimize errors, teachers need to ensure that students fully understand the problem to be solved so that the steps to solve it do not deviate from the correct procedure. In addition, students need to frequently practice fraction operations, especially division, by working on a variety of problems so that their process skills are further honed.

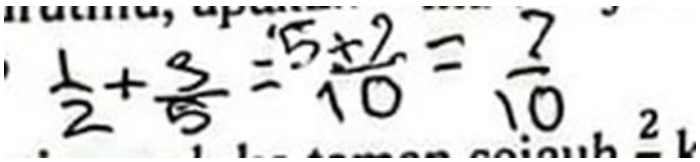

Figure 5. Example of student errors in Encoding Error.

Figure 5 shows student errors in the final answer writing stage. Students have performed the calculation process correctly, but did not write the conclusion according to the question in the problem. Instead of answering the question about the requested learning time, students only wrote the calculation results in fraction form. This shows that

even though the calculation was correct, the presentation of the final answer did not meet the requirements of the question. This finding is in line with the research by Nyamik et al. (2020), which reported that 70.66% of students experienced difficulties in the answer writing stage. The contributing factors include students' inability to find the keywords in the question properly, difficulty in reading symbols, not writing down the information that is known or asked, and not being able to determine the appropriate calculation or formula. As a result, students also failed to write the correct conclusion. Thus, weaknesses in the encoding stage are one of the important obstacles that need special attention in learning mathematical story problems.

Newman's Error Analysis proves diagnostically useful in mapping sequential breakdowns; however, the findings suggest that the five stages may not function strictly linearly. Errors at the transformation stage appear to cascade into process and encoding stages. This interdependence indicates that Newman's model should be interpreted dynamically rather than rigidly sequentially.

Another theoretical insight concerns the interaction between internal and external factors identified in the original study. Internal factors such as low motivation and limited conceptual mastery interact with external instructional strategies. Research by Mullis et al. (2021) indicates that teaching approaches emphasizing repetitive drill without representational diversity limit deep conceptual growth.

The study's context within the Merdeka Curriculum framework further underscores the importance of contextual and student-centered learning. Contemporary curriculum reforms emphasize problem-solving, reasoning, and communication. However, achieving these goals requires systematic scaffolding that bridges linguistic comprehension and symbolic modeling.

Pedagogically, the recommendation to utilize contextual media and gradual practice aligns with evidence supporting visual fraction models such as number lines and area diagrams (Hansen et al., 2022). Visual supports reduce cognitive load and enhance conceptual coherence. Scaffolded transformation exercises—explicitly teaching how to translate verbal statements into symbolic models—may address the representational gap identified.

In conclusion, this expanded analysis demonstrates that student errors in fraction word problems are multi-layered and interconnected. Transformation and process skills constitute the primary conceptual bottlenecks, influenced by representational fluency, cognitive load, and metacognitive regulation. Newman's framework remains relevant but requires integration with contemporary theories of representation and cognition to fully explain the "mystery" of student errors in mathematical story problems.

4 CONCLUSION

Based on the results of research on the difficulties of fourth-grade students at SDN Lubang Buaya 05 Pagi in solving math story problems involving fractions using Newman's Theory, it was found that the factors causing the difficulties stemmed from internal and external aspects. Internal factors included intelligence, interest, motivation, attitude, and the physiological condition of the students. Some students are not careful, get bored easily, are not interested in mathematics, and have not mastered the basic concepts of fractions, so they experience obstacles in understanding the meaning of the question, choosing the calculation operation, and writing down the final answer. Meanwhile, external factors are related to the teacher's learning strategies, which are still limited to reinforcing basic concepts without many story problems, the use of media that is not very varied, and a learning environment that is not fully conducive. The combination of these two factors gives rise to various types of errors according to Newman's Theory, such as errors in reading, understanding, transforming problems, performing process skills, and writing down the final answer.

To overcome these difficulties, teachers implemented several solutions, including strengthening students' understanding of basic fraction concepts, familiarizing students

with story problems through gradual practice from simple to complex problems, and utilizing contextual learning media such as pictures, concrete objects, and simulations of everyday life. In addition, scaffolding strategies are used to gradually guide students in converting story problems into mathematical models, and problems are presented in simple language so that they are easy to understand. With these steps, teachers are expected to be able to help students not only in mastering basic fraction concepts, but also in improving their skills in understanding the meaning of problems, choosing the right arithmetic operations, and writing down the final answer correctly.

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