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Newman's Error Analysis: The Student's Errors in Solving Word Problem of Proportion

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Abstract. Students' errors in solving mathematical problems need to be analyzed in depth so that teachers can choose the right way to anticipate the repetition of the same errors. This study aims to reveal the types of errors made by students in solving word problems on the topic of proportion. This study is a descriptive study with a qualitative approach. The subjects involved were two seventh grade students, male and female. The results of this study indicate that based on Newman's error analysis, male subjects mainly made reading errors, errors in understanding the problem, transformation errors, and writing the final answer that did not include a conclusion. While female subjects made errors in understanding the problem, choosing the operation used, and writing the conclusion sentence in the final answers. The results of this study can help students understand the errors made so that the errors are not repeated and can be input for teachers in improving the learning process.

Keywords: Newman's Error Analysis; Proportion; Students' Error; Word Problems

Abstrak. Kesalahan siswa dalam menyelesaikan masalah matematika perlu dianalisis secara mendalam sehingga guru dapat memilih cara yang tepat untuk mengantisipasi terjadinya pengulangan kesalahan yang sama. Penelitian ini bertujuan untuk mengungkap jenis-jenis kesalahan yang dilakukan oleh siswa dalam menyelesaikan soal cerita pada topik perbandingan. Penelitian ini merupakan penelitian deskriptif dengan pendekatan kualitatif. Subjek penelitian yang terlibat adalah dua siswa kelas VII, masing-masing berjenis kelamin laki-laki dan perempuan. Hasil penelitian ini menunjukkan bahwa berdasarkan analisis kesalahan Newman, subjek laki-laki melakukan kesalahan dalam membaca soal, memahami soal, kesalahan transformasi, dan kesalahan penulisan jawaban akhir yang tidak menyertakan kesimpulan. Sementara subjek perempuan melakukan kesalahan dalam memahami soal, memilih operasi yang digunakan, dan menulis kalimat kesimpulan dalam jawaban akhir. Hasil penelitian ini dapat membantu siswa dalam memahami kesalahan yang dilakukan agar kesalahan tidak terulang kembali dan dapat menjadi masukan bagi guru dalam memperbaiki proses belajar.

Kata kunci: Analisis Kesalahan Newman; Kesalahan Siswa; Soal Cerita; Topik Perbandingan

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INTRODUCTION

Mathematics holds an undeniable significance in education and human life, serving as a fundamental discipline that permeates various aspects of daily living. Its applications extend to fields such as economics, technology, and social dynamics, playing a critical role in driving advancements across diverse domains (Laila et al., 2019). A strong foundation in mathematical concepts is essential, as mastering this basic science not only supports the acquisition of other knowledge but also facilitates smoother learning processes for students (Yuliani et al., 2019). Consequently, mathematics education in schools aims to equip students with the ability to address real-world challenges effectively (Magfirah et al., 2019).

Despite its importance, students often struggle with mathematical problem-solving due to inadequate comprehension of underlying concepts (Raharti & Yunianta, 2020). These difficulties manifest in various forms of errors, which can be categorized using Newman's error analysis framework. This framework identifies five types of errors that may occur during problem-solving: errors in understanding the problem's content (reading errors), errors in interpreting the problem (comprehension errors), errors in transforming or altering the problem (transformation errors), errors in applying process skills (process skills errors), and errors in formulating conclusions (encoding errors) (Trapsilo, 2016).

An error can be defined as an inconsistency or deviation from the expected steps or procedures that have been previously established, or as a discrepancy that could have been anticipated and prevented (Yuliani et al., 2019). In the context of mathematics, errors are commonly interpreted as mistakes in mathematical calculations or problem-solving processes (Mukunthan, 2021). The occurrence of errors in learning serves as an important diagnostic tool, offering both students and teachers insights into ineffective aspects of the learning process during classroom interactions (Siyepu, 2015). Furthermore, errors made by students can be viewed as a valuable source of information about their understanding, providing researchers and educators with clues to uncover students' actual knowledge and misconceptions (Hérold, 2014).

Error analysis, as a diagnostic research method, plays a crucial role in helping teachers identify and understand the errors made by students, including the underlying reasons for these mistakes. More specifically, error analysis involves identifying, categorizing, and examining student errors to detect patterns and determine whether certain types of errors are consistently made (Ancheta & Subia, 2020). This process is essential for diagnosing the challenges and difficulties that students face during problem-solving, enabling teachers to address these issues and enhance the effectiveness of mathematics instruction (Sipayung & Anzelina, 2019).

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Error analysis serves as a critical starting point for understanding student learning, with the ultimate goal of enhancing students' comprehension of mathematical concepts (Kingsdorf & Krawec, 2014). Analyzing student errors in problem-solving is essential, as it helps identify the specific mistakes made by students and enables educators to provide targeted assistance. This process supports the selection of more effective instructional or intervention models, ensuring that similar errors are minimized or prevented in the future (Yuliani et al., 2019).

Students exhibit diverse types of errors when solving problems, reflecting their unique challenges and misconceptions (Raduan, 2010). Errors in one step of the problem-solving process can propagate to subsequent steps, ultimately hindering students' overall understanding and performance (Yuanita & Solfitri, 2014). Problem-solving, particularly in the context of mathematical story problems, generally involves several stages: reading and interpreting the problem, estimating or planning a solution, and calculating and recording the final answer (Riwayati & Andarini, 2022). Common errors in these stages often stem from factors such as insufficient mastery of mathematical language, misinterpretation of formulas, computational mistakes, carelessness, or a lack of conceptual understanding (Ramalisa & Syafmen, 2014).

Gender differences and learning style significantly influence variations in students' abilities and engagement in mathematics learning (Hidayah, 2012; Putra et al., 2020). Research indicates that male and female students exhibit distinct approaches to problem-solving (Febriyanti, 2016). In terms of classroom participation, female students tend to be more active in asking questions, while male students are generally less diligent in completing assignments given by teachers (Nikmah et al., 2020). These findings highlight that each student possesses unique characteristics and thought processes, with gender differences playing a critical role in shaping these variations (Riadi et al., 2022).

Male and female students also demonstrate differing levels of understanding and proficiency in certain mathematical topics. For instance, female students have been found to exhibit greater interest and curiosity in problem-solving and employ more varied approaches compared to their male counterparts (OECD, 2014; Khotimah et al., 2022). These differences in learning outcomes and strategies underscore the need for tailored teaching methods that accommodate gender-specific learning preferences.

Errors in solving mathematical problems commonly occur when students encounter story problems that require multi-step reasoning (Gunawan, 2017). One such topic in mathematics closely tied to everyday life and often presented through story problems is proportion. Proportion

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involves comparing two or more quantities of the same type, expressed in a manner that facilitates comprehension (Hoar et al., 2021). Proportional reasoning encompasses two primary concepts: worth proportion, which represents a relationship where one quantity increases in tandem with another, and inverse proportion, which represents a relationship where one quantity decreases as the other increases (Wulanningtyas et al., 2022).

Therefore, this research aims to assess the necessity of analyzing the types of errors made by students when solving story problems on the topic of proportion, using the Newman error analysis framework. While several studies have utilized the Newman framework to analyze student errors, these have predominantly focused on topics such as two-variable linear equation systems (Afriandani et al., 2022), geometry (Magfirah et al., 2019), and linear program (Oktafia et al., 2020). However, there is limited research addressing errors related to proportion, a fundamental mathematical concept that is closely tied to real-world applications. Thus, this study seeks to fill this gap by identifying and categorizing the specific types of errors students make when solving story problems on the topic of proportion.

The findings of this study are expected to provide valuable insights for educators, serving as a basis for improving instructional practices in the classroom. By understanding the patterns and causes of errors, teachers can design more effective interventions and instructional strategies to address students' difficulties. Ultimately, the results of this research aim to contribute to enhancing the overall quality of mathematics learning, fostering a deeper understanding of proportion among students, and equipping them with essential problem-solving skills.

METHOD

This study employs a descriptive methodology with a qualitative approach, selected to systematically investigate and analyze the various types of errors committed by students when solving word problems on the topic of proportion. The research was involved seventh-grade students from a private Islamic junior high school located in Donggala, Central Sulawesi, providing a contextual basis for understanding the challenges faced by learners in this region.

The data collection techniques employed in this study are tests and interviews. The researcher served as the primary instrument, while the test items and interview guidelines functioned as supporting instruments. The test consisted of two problems: one addressing inverse proportion problems and the other focusing on worth proportion problems. Prior to their implementation, the problems underwent a rigorous validation process by experts in mathematics education to ensure their clarity, relevance, and alignment with the study's objectives. The two problems are presented below.

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1. *A farmer has a supply of animal feed for 42 chickens for 20 days. The farmer has sold 12 of his chickens. How long will the feed last with the same supply?*
2. *A beverage factory has a snack packaging machine that can package 180 snacks every 120 seconds. How many snacks can be packaged in 4 minutes?*

The researcher administered the two problems to a group of 18 seventh-grade students. The students' responses were then analyzed to identify the types of errors they made, using Newman's Error Analysis framework as a reference. This framework facilitated the systematic classification of errors into distinct categories, providing insights into the specific challenges faced by students. The findings from this analysis, detailing the types of errors identified, are summarized and presented in Table 1.

Table 1. The Findings of Student Errors in Solving Word Problems on Proportion Topic

Type of Errors	Student Number	Description
Reading Error	10	Students struggle to correctly read terms, units, or symbols, and have difficulty understanding the meanings of complex terms.
Comprehension Error	10, 17	Students fail to include important details when answering the question due to difficulty in understanding the essence of the question.
Transformation Error	10, 17	Students make mistakes in determining the type of operation needed to solve the problem.
Process Skills Errors	None	Students make errors in applying the appropriate mathematical principles or norms.
Encoding Error	10, 17, 8, 6	Students fail to write the conclusion in complete sentence form.

Subsequently, the researcher selected two students as the primary research subjects, one male and one female, to represent their respective genders. The selection process was guided by specific criteria, including the variety of errors observed in their responses to story problems, their willingness to actively participate in the study, their ability to articulate their thought processes effectively during the research, and recommendations provided by their mathematics teacher based on their classroom performance and behaviors. These criteria ensured that the chosen subjects could provide rich and representative data for the study.

Based on the data presented in Table 1 and the fulfillment of the subject selection criteria, the researcher identified two students as research subjects: Subject 10, referred to by the initials IS, representing the male gender, and Subject 17, referred to by the initials NV, representing the female gender. This selection ensured the inclusion of diverse perspectives and error patterns, aligning with the study's objectives to explore gender-based variations in problem-solving errors.

To gain a deeper understanding of the types of errors made by the students, the two research subjects were interviewed individually. This approach allowed for a more focused and detailed exploration of their thought processes, error patterns, and the underlying factors contributing to

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their responses. The separate interviews provided an opportunity to capture the unique perspectives of each subject, enriching the analysis of the data collected during the test phase.

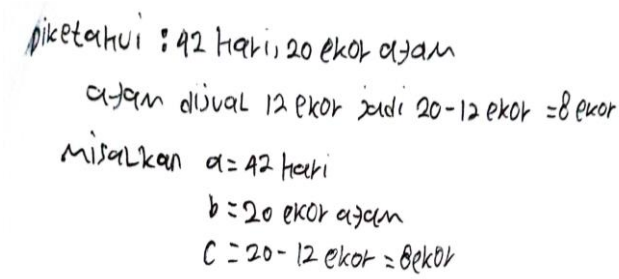
Data analysis was carried out by referring to qualitative data analysis, namely: data condensation, data display, and drawing conclusions/verification (Miles et al., 2014). Meanwhile, the validity of the data obtained was checked by member checking, namely the process of verifying data against its source. The purpose of member checking is to ensure that the data obtained in the study is in accordance with the original intent of the data or informant (Mekarisce, 2020).

RESULTS AND DISCUSSION

Male Subject (IS) Work

Problem 1

When solving problem 1, IS made a mistake in reading the question (reading error) so that the written information 42 chickens was read 42 days and 20 days was read 20 chickens. Based on the interview, IS admitted that he was not focused on reading the question. IS also did not present the available information pairs in the form of a table to understand the relationship between the quantities given. This also indicates that IS did not understand the available information well (comprehension error). So IS also made a mistake in assuming the number of chickens and the initial day and determining the number of chickens after 12 chickens were sold. IS's answer containing the three errors is presented in Figure 1.



Translation

Given: 42 days, 20 chickens

Sold 12 chickens, so there are 20-12 = 8 chickens

Let a = 42 days

b = 20 chickens

c = 20-12 = 8 chickens

Figure 1. IS Made a Reading Error Which Resulted in Other Errors

Due to IS made a mistake in understanding the number of chickens and the number of days even though he had used the correct formula, the calculation results were still wrong. In addition to getting the wrong results, IS also did not try to translate the calculation results into a sentence as a conclusion (encoding error). Both errors can be seen in Figure 2.

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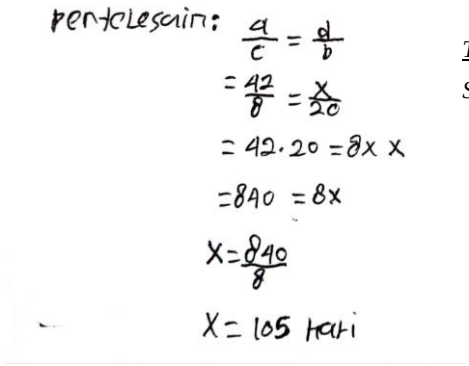


Translation

Solution: a : c = d : b

42 : 8 = x : 20

42.20 = 8.x

840 = 8x

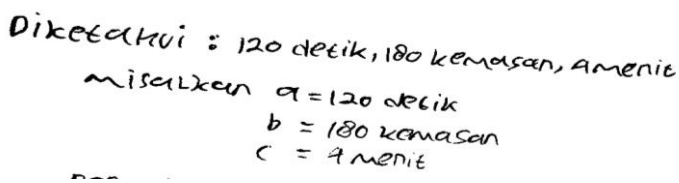
x = 840/8

x = 105 days

Figure 2. IS Made a Mistake in Using the Worth Proportion Formula

Problem 2

In solving problem number 2, IS made a mistake in understanding, namely not understanding that the quantity to be operated must have the same unit (comprehension error) so that IS did not change the time unit from minutes to seconds so that it could be operated correctly. In addition, IS also did not present pairs of information in a table to understand the relationship between the quantities given. The errors are are presented as Figure 3.



Translation

Given: 12 seconds, 180 snacks, 4 minutes

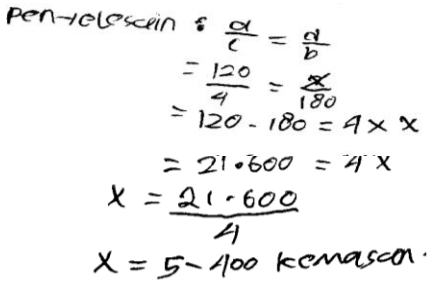
Let a = 120 seconds

b = 180 snacks

c = 4 minutes

Figure 3. IS did not Change the Time Unit from Minutes to Seconds or Vice Versa

IS also made a mistake in choosing the formula used (transformation error). Problem 2 should have been solved with the worth proportion formula, but IS chose to use the inverse proportion formula. The algebraic manipulation carried out was correct even though it produced the wrong answer. There was no attempt to make a conclusion in the form of a sentence (encoding error). The error is presented in Figure 4.



Translation

Solution: a : c = d : b

120 : 4 = x : 180

120.180 = 4.x

21600 = 4x

x = 21600/4

x = 5400 snacks

Figure 4. IS Made a Mistake in Choosing the Formula

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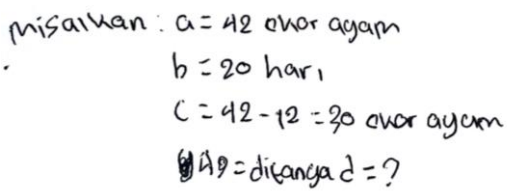
Female Subject (NV) Work

Problem 1

In NV's answer to problem 1 presented in Figure 5, NV did not present information on the number of chickens and days in a table to make the problem easier to understand. NV admitted that she did not need a table as an aid. So there was an error in assuming the known quantity (comprehension error).

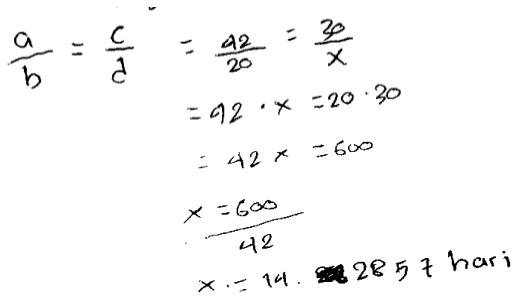


Translation

Let a = 42 chickens
b = 20 days
c = 42-12 = 30 chickens
Find d = ?

Figure 5. NV does not Understand the Available Information Pairs

In addition, due to not understanding the problem, NV also made an error in choosing the proportion formula (transformation error). Problem 1 is an inverse proportion problem, but NV used the worth proportion formula. As a result, even though NV did the algebraic manipulation well, she did not get the correct results. NV also did not try to present the conclusion of the calculation results in the form of a sentence (encoding error). Both errors are shown in Figure 6.



Translation

a : b = c : d = 42 : 20 = 30 : x
42.x = 20.30
42x = 600
x = 600/42
x = 14,2857 days

Figure 6. NV Made a Mistake in Using the Inverse Proportion Formula

Problem 2

Figure 7 shows NV's answer to problem 2. NV also did not create a proportion table to make it easier to understand the problem so that NV did not understand the available information pairs well (comprehension error). NV also did not change the time unit from minutes to seconds or vice versa so that it could be operated correctly.

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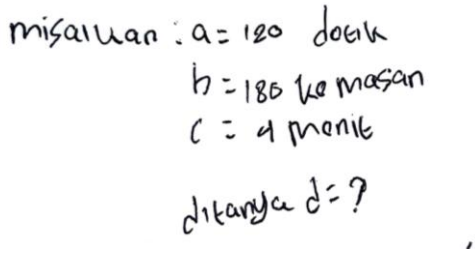
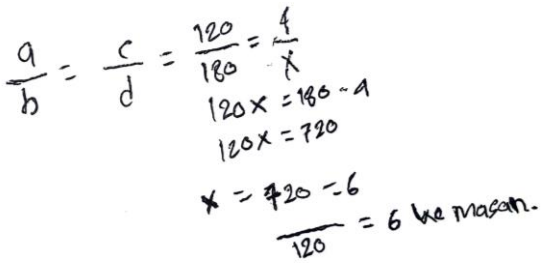


Translation

Let a = 120 seconds
b = 180 snacks
c = 4 minutes
Find d = ?

Figure 7. NV does not Convert Time Units to the Same Units

Although NV performed algebraic manipulation correctly, because the quantities operated were incorrect, NV also produced the wrong answer. NV also did not conclude the calculation results in the form of meaningful sentences (encoding error). NV's answer are presented as Figure 8.



Translation

Solution: a : b = c : d
120 : 180 = 4 : x
120.x = 180.4
120x = 720
x = 720/120
x = 6 snacks

Figure 8. NV did not Make Any Conclusions

The Error of Male Subject in Solving Word Problem

Gender differences significantly influence variations in students' abilities and engagement in mathematics learning (Hidayah, 2012). The male subject in this study demonstrated several errors during problem-solving, starting with a reading error. He misinterpreted the problem by exchanging unit of the given quantities or information. This error could have been avoided if he had organized the information in a table, as this would have clarified the relationships between the data provided. However, he opted not to use a table, as he perceived it as unnecessary. This finding aligns with previous research suggesting that male students are generally less diligent in completing assignments and often neglect strategies that could aid their problem-solving processes (Nikmah et al., 2020). Moreover, even when reading errors are not present, other studies reveal that some students still struggle to comprehend the problems they are tasked with solving (Labibah et al., 2021). In addition to the reading error, the male subject failed to recognize that quantities being operated on must have consistent units, leading him to perform operations on values with differing units, which further complicated his solution.

Another prominent mistake made by the male subject was in selecting the correct formula to solve the problem. He consistently applied the inverse proportion formula to all problems, regardless of whether the situation required a worth or inverse proportional relationship. This

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indicates a lack of understanding in distinguishing between worth proportion, where one quantity increases in tandem with another, and inverse proportion, where one quantity decreases as the other increases (Wulanningtyas et al., 2022). The male subject's inability to identify the appropriate formula suggests a conceptual misunderstanding that influenced his overall problem-solving process.

Additionally, the male subject often failed to draw conclusions from the results of his calculations. He tended not to write a final answer or conclusion in sentence form, which is a common error among students. Research indicates that many students struggle to articulate the final conclusions of their solutions due to difficulty in translating mathematical results into coherent sentences (Labibah et al., 2021). This issue highlights the importance of developing students' abilities to express their final answers clearly, as it reflects their understanding of the problem and its solution.

The Error of Female Subject in Solving Word Problem

In solving mathematical problems, male and female students exhibit distinct differences (Febriyanti, 2016). For example, while the female subject did not make reading errors like the male subject, she struggled to fully understand the problem. This aligns with findings that male and female students demonstrate variations in their ability to comprehend certain materials, particularly in mathematics (Khotimah et al., 2022). To better grasp the problem, the female subject could have organized the known information into a simple table, which would have helped establish clear connections between the given quantities.

One notable error made by the female subject was selecting the wrong formula to solve the problem. This issue is commonly observed among students who lack knowledge of the steps or methods required for problem-solving (Salamah & Risma, 2020). In this case, the female subject consistently applied the worth proportion formula to all problems, even when the problem required an inverse proportion formula. Such errors reflect a misunderstanding of fundamental concepts: worth proportion involves a relationship where quantities increase together, while inverse proportion involves a relationship where one quantity increases as the other decreases (Wulanningtyas et al., 2022).

Furthermore, the female subject failed to recognize that the quantities being operated on must have consistent units. Consequently, she performed operations on values with differing units, compounding the error in her calculations. These challenges are typical when students are faced with story problems requiring multi-step reasoning, where errors often arise from difficulties in identifying and applying appropriate operations (Gunawan, 2017). Transformation errors, such as

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choosing incorrect arithmetic operations, are particularly common and hinder students' ability to progress through problem-solving steps effectively (Hoar et al., 2021).

In addition to these errors, the female subject also struggled with writing the final answer. She did not provide conclusions in the form of complete sentences, a mistake often attributed to students' difficulties in articulating mathematical results clearly. Despite these errors, it is worth noting that female students generally exhibit greater interest and curiosity in problem-solving and employ more varied approaches compared to their male counterparts (OECD, 2014). This suggests that while female students may encounter specific conceptual challenges, their intrinsic motivation and diverse problem-solving strategies present opportunities for targeted interventions to enhance their mathematical understanding and performance.

CONCLUSION

Both male and female students made three types of errors, namely comprehension errors, transformation errors, and encoding errors. Comprehension errors are seen from students' inability to present known information in the form of a table to ensure the relationship between the given quantities. Meanwhile, transformation errors occur because male students tend to use the inverse proportion formula to solve all problems and conversely female students tend to always use the worth proportion formula. An interesting thing is that no process skill errors were found because both students could do algebraic manipulation correctly even though the resulting answers were wrong. In addition, there was no apparent effort by students to make conclusions in the form of sentences. Meanwhile, reading errors were only experienced by male students, they were not careful in reading the units of quantities. This study is expected to provide insight for teachers to improve the learning process of proportion topics so that students can solve problems without errors.

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