

ANALYSIS OF STUDENT ERRORS BASED ON NEWMAN'S THEORY IN SOLVING CONTEXTUAL PROBLEMS ON PROBABILITY

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Abstrack

Mathematics instruction is essential for fostering logical thinking, organized reasoning, and the ability to tackle problems. Yet, in reality, numerous learners continue to face challenges when dealing with real-world problems, especially in the area of probability. The objective of this research is to examine the mistakes made by students when applying Newman's Theory to solve real-world issues in probability. This study employs a qualitative approach using error analysis as the research method. Research subjects were selected using purposive sampling, specifically students who had studied probability. A total of 22 students participated in this study. Data gathering was carried out using written assessments featuring open-ended queries and interviews to understand the ways students think when tackling problems. The analysis of the data was performed utilizing the Newman method, which comprises reading mistakes, misunderstanding errors, transformation mistakes, procedural skill errors, and encoding mistakes. The findings from the research reveal that students made errors as follows: reading mistakes accounted for 4.54%, comprehension errors were at 10.6%, transformation mistakes reached 25.75%, process skill errors were at 36.36%, and encoding mistakes, which were the most common, were at 45.45%. These results show that learners continue to encounter major challenges when it comes to documenting step-by-step solution methods and delivering correct final responses that fit the situation of the problem. This study implies that mathematics instruction needs to emphasize conceptual understanding, mathematical modeling skills, and the practice of solving problems in a structured manner.

Kata Kunci: *Newman Error Analysis, Probability, Contextual Problems, Error Analysis, Mathematics Education.*

A. Introduction

Mathematics is a key subject in education as it fosters the development of logical, structured, analytical, and inventive thinking abilities. By learning mathematics, students should not only grasp concepts and methods but also utilize these ideas to tackle different

problems that arise in everyday life (Setiyawati et al. , 2022). Therefore, the mathematics learning process should not only focus on mastering formulas but also on problem-solving skills.

A method to enhance students' abilities in solving problems is by using real-life scenarios. Contextual problems are questions linked to real-life situations, requiring students to understand the information provided, determine a solution strategy, and perform calculations accurately. However, in reality, many students still struggle when solving contextual problems. These difficulties often lead students to make various mistakes in the process of solving mathematical problems (Fitri & Abadi, 2021).

Errors made by students when solving math problems can result from various factors, such as a lack of conceptual understanding, misinterpretation of information in the problem, or errors in the calculation process. Therefore, an analysis of student errors is necessary so that teachers can identify the types of errors that occur and their causes. By examining this error analysis, educators can create better teaching methods to enhance students' comprehension of mathematical ideas (Logistica and Awalludin, 2024).

One of the topics in mathematics that often poses difficulties for students is probability. Probability requires students to understand the information in a problem, identify the appropriate mathematical model, and perform calculations correctly. Research shows that students often struggle with solving probability problems, particularly in the stages of understanding the problem, determining a solution strategy, and writing the final answer (Irianti et al., 2024).

One analytical framework that is widely used to investigate students' difficulties in mathematical problem solving is Newman's Error Analysis (NEA). This framework enables researchers to systematically identify the stages at which students experience obstacles while solving mathematical problems, particularly contextual and procedural tasks. According to Newman, students' errors can be classified into five sequential stages: reading, comprehension, transformation, process skills, and encoding (Irianti et al., 2024). Rather than merely categorizing mistakes, NEA provides insight into the cognitive processes underlying students' responses and reveals how early-stage misunderstandings may influence subsequent stages of problem solving.

The application of Newman's framework is particularly relevant in probability learning because solving probability problems requires students not only to understand

contextual information but also to transform that information into appropriate mathematical representations and execute calculations systematically. Previous studies have shown that students frequently encounter difficulties in connecting conceptual understanding with procedural execution, resulting in errors that persist throughout the solution process. In this regard, NEA serves as an effective diagnostic framework for identifying the specific sources of students' misconceptions and procedural weaknesses. Furthermore, the findings generated through Newman-based analysis can provide empirical evidence for developing instructional strategies that emphasize conceptual understanding, mathematical reasoning, and structured problem-solving skills (Logistica & Awalludin, 2024).

Based on the discussion above, a thorough examination of the mistakes students make when addressing contextual issues concerning probability is essential. While earlier research has applied the Newman method to pinpoint errors students make in tackling math problems, there is still a lack of studies that focus specifically on mistakes students make in probability, particularly regarding the cognitive processes involved in converting context-specific problems into mathematical representations. Consequently, this research seeks to evaluate students' mistakes following Newman's Theory in addressing contextual challenges related to probability. By conducting this evaluation, the research aims to provide a clearer understanding of the difficulties faced by students, which can then aid in developing more effective strategies for teaching mathematics to enhance students' problem-solving abilities.

B. Metode Penelitian

This study employs a qualitative approach using error analysis. The reason for selecting a qualitative method is that the research seeks to thoroughly explore the mistakes that learners commit while tackling real-life issues related to probability.

The research subjects were students who had studied probability. The subjects were selected using purposive sampling, which involves intentionally selecting subjects based on specific criteria aligned with the research objectives

The techniques for gathering information in this research involved both written assessments and interviews. Students completed a written assessment which consisted of essay questions focused on real-life issues related to probability topics. Through this test, the researcher could observe the steps students took to solve the problems, allowing for

an analysis of the errors that occurred. Additionally, interviews were conducted to obtain more in-depth information regarding the reasons students made errors during the problem-solving process.

The research instruments used in this study were open-ended test questions on probability and interview guidelines. The test questions were designed to assess students' ability to understand problems, identify mathematical models, perform calculations, and write down their final answers.

Table 1. Essay Test Questions

No	Question
1	In a box, there are 12 red balls, 8 blue balls, and 10 yellow balls. If a ball is selected at random, what is the probability that it will be a red ball or a yellow ball?
2	Two dice are rolled together once. Determine the probability that the first die shows an even number and the second die shows a prime number!
3	Of the 30 students in the 10th-grade class at GKPI Padang Bulan High School, 15 like math, 10 like economics, and 5 like both. If one student is chosen at random, determine the probability that the student likes only math.

The method of data analysis applied in this research adheres to the stages of Newman's Error Analysis, specifically: (1) reading error, which examines if learners are able to read the question accurately, (2) comprehension error, which assesses whether students grasp the information within the problem, (3) transformation error, which evaluates students' capability to convert the problem into a mathematical representation, (4) process skills error, which looks into students' proficiency in executing calculation processes, and (5) encoding error, which checks students' skill in correctly recording the final answer.

The information gathered was examined in three phases: condensing data, displaying data, and reaching conclusions. By following this investigative approach, the researcher was able to pinpoint the kinds of mistakes that students commonly encountered while working on probability issues, along with the reasons behind those mistakes.

C. Result and Discussion

Result

Table 2. Results of the Analysis of Student Responses Using Newman's Theory

Student	Question 1	Question 2	Question 3
S1	-	-	-
S2	-	-	-
S3	-	-	-
S4	-	-	-
S5	-	-	-
S6	-	4	4, 5
S7	-	-	-
S8	5	4	3, 4, 5
S9	5	4	3, 4, 5
S10	-	-	1, 2, 3
S11	-	-	1, 2, 3
S12	-	5	3, 4
S13	-	-	-
S14	-	3, 4	3, 4
S15	-	3, 4	5
S16	-	3	1, 2, 3, 4, 5
S17	4	3, 4	3, 4, 5
S18	4	3, 4	4, 5
S19	-	-	-
S20	3	3	4
S21	-	3	-
S22	-	-	-

According to the information in Table 1 mentioned earlier, the mistakes that students made when responding to questions 1, 2, and 3 were recognized and examined through the lens of Newman's Theory.

Reading Error

This reading error is often found in students' answers to Question 3. Below is a sample answer for S16.

Question 3

Of the 30 students in the 10th-grade class at GKPI Padang Bulan High School, 15 like mathematics, 10 like economics, and 5 like both. If one student is chosen at random, determine the probability that the student likes only mathematics.

3. dik: menyukai mtK (15)
ekonomi (10)
keduanya (5)

$$n(S) = 15 + 10 + 5 = 30$$

$$n(A) = 15 + 5 = 20$$

$$P(A) = \frac{20}{30} = \frac{5}{10} = \frac{1}{2}$$

Figure 1. Answer S16 with a Reading Error

Based on Figure 1, a reading error was identified: The inquiry required students to determine the likelihood of those who enjoy mathematics exclusively, yet the response from the student computed the overall probability of the event $n(A)$ by combining the count of students who appreciate mathematics with those who are fond of both subjects. Furthermore, when writing the total probability of the event, the student wrote $n(S)$. Therefore, S16 made a reading error.

Comprehension Error

Just like reading errors, comprehension errors are often found in students' answers to question 3. Here is a sample answer for S11.

3. dik: total siswa = 30
 $n(M) = 15$
 $n(E) = 10$ siswa
 $n(M \cap E) = 5$ siswa

Jawaban: $n(M) - n(M \cap E)$
 $= 15 - 5 = 10$ siswa $q = \frac{5}{10}$

$p = \frac{10}{30} = \frac{1}{3}$ siswa
 $p = \frac{10}{10} = \frac{1}{1}$ siswa

Figure 2. Answer S11 with a Comprehension Error

From the results in Figure 2, where the inquiry required students to determine the likelihood of those who enjoy only mathematics, yet their calculations for the probability of event $n(A)$ produced two distinct outcomes: one by subtracting the number of students who like mathematics from the total number of students who like both subjects which is the correct probability and another by subtracting the number of students who like only mathematics from the intersection of students who like mathematics and those who like

economics. Therefore, S11 has an inconsistent understanding or has not fully grasped what the probability of the event being asked for in the question is supposed to be.

Transformation Error

This transformation error is often found in students' answers to questions 2 and 3. Below is a sample answer for S8 on question 2.

Question 2

Two dice are rolled together once. Determine the probability that the first die shows an even number and the second die shows a prime number!

2. Dik : - angka genap di dadu = 2, 4, 6 → ada 3 kemungkinan
- angka prima di dadu = 2, 3, 5 → ada 3 kemungkinan
Dit : P(A ∩ B) = ... ?
Jwb : P(A ∩ B) = P(A) × P(B)
$$= \frac{1}{2} \times \frac{1}{2}$$
$$= \frac{1}{4}$$

Figure 3. Answer S8 with a Transformation Error

Figure 3 reveals a transformation error, in which Student S8 did not describe the process of determining the probability of rolling an even number and the probability of rolling a prime number. Although the student's answer was correct, this demonstrates that Student S8 is capable of transforming information from a word problem into a mathematical model.

Process Skill Error

This process-related error is frequently found in students' answers to questions 2 and 3. However, the researcher selected sample answer S17 for question 2.

2. total kemungkinan dua dadu = 6 × 6 = 36
kemungkinan → manenchi = 3 × 3 = 9
peluang =
 $\frac{9}{36} = \frac{1}{4}$
jawab: $\frac{1}{4}$

Figure 4. Answer S17 with a Process Skill Error

Figure 4 reveals a process-skill error, in which Student S17 did not describe the process for calculating probability. The student S17 was expected to explain the process or apply

the formula for computing probability, which is determined by dividing the count of successful outcomes by the overall number of attempts. Furthermore, Student S17 did not accurately describe the calculation process and did not include the formula, even though the final answer provided was correct. Although the student's answer was correct, it demonstrates that Student S17 is not yet able to describe the procedure in a logical sequence.

Encoding Error

This encoding error is frequently found in students' answers to questions 1 and 3. However, the researcher selected a sample of S9's answers to question 1.

Question 1

In a box, there are 12 red balls, 8 blue balls, and 10 yellow balls. If one ball is drawn at random, what is the probability of drawing a red ball or a yellow ball?

7. Dik : 12 Bola merah, 8 biru, 10 bola kuning
Dit : probabilitas peluang terambil bola merah /
Bola kuning ?
= $\frac{M}{N} = \frac{12+8+10}{30}$
= $\frac{MCA}{NCS}$
= $\frac{12+10}{30}$
= $\frac{22}{30}$
= $\frac{22}{30}$

Figure 5. Answers S9 with a Encoding Error

Figure 5 reveals an encoding error, in which Student S9 failed to document the process of finding the probability. When writing the final answer, the probability must be expressed in its simplest form to ensure accuracy and neatness. Furthermore, Student S9 frequently made errors in writing the final answers on other questions. This may have occurred because the student was in a hurry, lacked attention to detail, or was not accustomed to simplifying fractions.

Based on the analysis of students' answers to questions 1, 2, and 3, It was observed that learners committed different kinds of mistakes at every phase of problem-solving based on Newman's method. These mistakes consist of misreading, misunderstanding, errors in transformation, mistakes in process skills, and errors in encoding. Each kind of mistake showed different levels of occurrence throughout the questions, suggesting that students face challenges in resolving contextual issues related to probability at various

stages rather than just at one specific point. Consequently, to better understand the error patterns exhibited by students, a percentage analysis was performed for each mistake type, considering how often they appeared in all student responses. The findings from these percentage calculations of errors are displayed in the table that follows.

Table 3. Percentage of Errors in Students' Answers

From of error	Q1	Q2	Q3	Percentage of Mean
Reading Error	0	0	3	4,54%
Comprehension Error	0	1	6	10,6%
Transformation Error	1	7	9	25,75%
Process Skill Error	3	9	12	36,36%
Encoding Error	4	10	15	45,45%

Discussion

The findings of this study demonstrate that students experienced difficulties at almost every stage of problem solving based on Newman's Error Analysis (NEA), namely reading, comprehension, transformation, process skills, and encoding errors. However, the dominant errors occurred at the process skills and encoding stages. These findings indicate that students' difficulties in probability are not merely related to understanding the problem statement, but are more strongly associated with procedural reasoning, mathematical communication, and the ability to present solutions systematically.

The percentage of reading errors was relatively low (4.54%), indicating that most students were able to recognize symbols, keywords, and information contained in the problem statements. Nevertheless, several students still misread important information or failed to distinguish between terms such as "only mathematics" and "mathematics and economics." This finding suggests that although students can read the text linguistically, they may still experience difficulties in interpreting mathematical meaning within contextual situations. According to Newman's framework, reading is the initial stage that influences subsequent stages of problem solving. Therefore, even small inaccuracies at this stage may lead to larger conceptual errors in later stages.

Comprehension errors accounted for 10.6% of the total errors. This indicates that some students were unable to fully understand the meaning of the problem or identify what was actually being asked. For example, several students incorrectly interpreted the concept of "only mathematics" in Question 3, resulting in inconsistent reasoning and incorrect probability determination. These findings reveal that students still struggle to

connect contextual information with mathematical concepts. This result is consistent with previous studies stating that students often experience difficulties in identifying relevant information in word problems because they tend to focus on numerical values rather than conceptual relationships (Setiyawati et al., 2022; Logistica & Awalludin, 2024). In the context of probability learning, conceptual understanding plays a crucial role because students must interpret events, sample spaces, and relationships among events before performing calculations.

Transformation errors reached 25.75%, indicating that many students encountered difficulties when converting contextual problems into mathematical representations. At this stage, students were expected to formulate mathematical models, determine appropriate formulas, and identify relationships between known and unknown variables. However, several students directly wrote answers without explaining the mathematical transformation process. This condition reflects that students tend to rely on intuition or memorization rather than analytical reasoning. In Question 2, for instance, some students correctly identified the final probability but failed to represent the problem using formal probability notation or multiplication rules.

These findings strengthen previous research showing that transformation errors frequently occur because students are not accustomed to translating verbal information into symbolic mathematical forms (Prengki et al., 2024). In addition, students often use shortcut strategies without understanding the underlying concepts. From a cognitive perspective, this phenomenon indicates that students have not yet developed adequate mathematical modeling skills. Mathematical modeling ability is essential in probability learning because students must interpret real situations into structured mathematical representations before determining solutions. Therefore, mathematics instruction should emphasize contextual learning approaches that encourage students to explicitly identify known information, formulate mathematical models, and justify the formulas they use.

Process skills errors constituted 36.36% of the total errors, making them the second most dominant category. These errors occurred when students failed to perform calculations systematically, omitted important procedural steps, or used inappropriate operations during problem solving. Several students directly wrote answers without demonstrating the probability calculation process, while others made mistakes in

arithmetic operations or failed to simplify fractions correctly. These findings indicate that students' procedural fluency in probability remains weak.

The high percentage of process skills errors suggests that students tend to memorize formulas mechanically without understanding the logic behind the procedures. This finding aligns with the study conducted by Irianti et al. (2024), which reported that procedural errors commonly arise when students rely heavily on rote learning and have limited opportunities to practice structured problem solving. Furthermore, students' inability to explain calculation steps demonstrates weaknesses in mathematical reasoning and communication. In probability learning, procedural understanding is not only related to obtaining correct answers but also to demonstrating logical reasoning through systematic solution steps. Therefore, teachers need to provide scaffolded learning experiences that guide students in explaining each stage of the calculation process clearly and logically.

The most dominant error identified in this study was encoding error, with a percentage of 45.45%. This finding indicates that many students experienced difficulties in presenting final answers accurately and completely. Common mistakes included failing to simplify fractions, omitting conclusions, writing answers inconsistent with the context of the problem, and neglecting probability notation. Although some students obtained correct calculations, they failed to communicate the final answer appropriately.

This phenomenon suggests that students tend to underestimate the importance of the final stage of problem solving. Many students appear to focus primarily on obtaining numerical results without rechecking whether the answers correspond to the questions asked. Similar findings were reported by Monika et al. (2025), who stated that students frequently ignore the accuracy and completeness of final conclusions because they perceive the final stage as less important than the calculation process itself. In fact, according to Newman's theory, encoding is a critical stage because it reflects students' overall understanding and ability to communicate mathematical ideas.

The dominance of encoding errors also indicates weaknesses in students' mathematical communication skills. Students are not yet accustomed to expressing mathematical conclusions systematically using appropriate notation and contextual explanations. This finding is in line with Nuraina et al. (2023), who emphasized that mathematical communication ability strongly influences students' success in presenting

complete and accurate solutions. Consequently, mathematics instruction should not only prioritize procedural accuracy but also encourage students to write conclusions explicitly, use appropriate mathematical notation, and verify whether their final answers align with the problem context.

Overall, the findings of this study confirm that students' difficulties in solving contextual probability problems are multidimensional. The errors identified do not occur independently but are interconnected across the stages of Newman's procedure. Students who experience comprehension difficulties are more likely to make transformation and procedural errors, which eventually lead to incorrect final answers. Therefore, improving students' probability problem-solving ability requires comprehensive instructional strategies that integrate conceptual understanding, mathematical modeling, procedural fluency, and mathematical communication.

From a pedagogical perspective, the findings of this study provide important implications for mathematics instruction. First, teachers should design learning activities that emphasize conceptual understanding rather than memorization of formulas. Second, students need more opportunities to practice solving contextual probability problems through structured and guided approaches. Third, teachers should encourage students to explain their reasoning processes verbally and in written form to strengthen mathematical communication skills. Finally, reflective activities such as checking answers, discussing alternative solutions, and identifying errors should become integral parts of mathematics learning.

This study contributes theoretically by providing empirical evidence regarding the distribution of Newman's error types in probability learning contexts. In addition, the study contributes practically by identifying specific areas where instructional intervention is required to reduce students' errors in solving contextual probability problems. However, this study has several limitations. The research involved a limited number of participants and focused only on probability material. Therefore, future studies are recommended to involve larger samples, examine different mathematical topics, and explore the effectiveness of instructional models specifically designed to minimize Newman's error stages in mathematics learning.

D. Conclusion

Based on the research findings, it can be inferred that learners continue to commit different kinds of mistakes while addressing real-world problems related to probability concepts. This observation is analyzed through Newman's Theory, which identifies issues such as reading mistakes, understanding errors, transformation mistakes, procedural skill errors, and encoding mistakes. Among these five categories of mistakes, the most common arise during the stages of process skills and the recording of the final answer, indicating that students remain weak in systematically following problem-solving procedures and are less meticulous in writing down final results. Furthermore, the research findings also indicate that students' difficulties are not limited to the stage of understanding the problem but also extend to their ability to translate information into mathematical models and perform calculations correctly. This suggests that students' conceptual understanding and mathematical modeling skills still need to be improved so that they can solve problems accurately and in a structured manner. Therefore, mathematics instruction should be designed to place greater emphasis on reinforcing conceptual understanding, providing ongoing practice, and fostering the habit of solving problems systematically and thoroughly. In this way, it is hoped that student errors at each stage can be minimized and students' mathematical problem-solving skills can be optimally enhanced. Further research is recommended to develop an instructional approach or model that can minimize student errors at each stage of the Newman procedure and to test it on other mathematical topics and in broader learning contexts.

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