



Analysis of Student Errors in Solving Problems Involving Curved-Surface Geometric Shapes Based on Newman's Error Analysis

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Abstract

This study aims to evaluate the errors made by students when solving problems involving three-dimensional shapes with curved sides, using Newman's error analysis approach. The research employed a descriptive qualitative method and was conducted at Imelda Private Junior High School in Medan during the second semester of the 2025/2026 academic year, with the participation of 18 students selected through purposive sampling. Data collection tools consisted of written tests, interviews, and documentation. Data analysis was conducted by referring to Newman's five stages of error: reading, comprehension, transformation, process skills, and coding.

The research findings indicate that the most common errors were process skill errors, accounting for 25.9%, and transformation errors, accounting for 20.3%, while errors in the reading, comprehension, and coding stages were not identified. Students with low ability typically struggle to find the formula and proceed with the problem-solving process; students with moderate ability tend to make errors during calculations; whereas high-ability students successfully solve problems accurately and in an organized manner.

Thus, it can be concluded that most student errors are caused by an inability to select the correct formula and a lack of precision during calculations. Therefore, it is crucial to implement teaching methods that focus on conceptual understanding and procedural skills to minimize the errors students make when tackling mathematical problems.

Keywords: *NewmanAnalysis; ErrorPattern; ProcessSkill; Transformation; CurvedSurfaceGeometry*

1. Introduction

Mathematics is a field of study that plays a crucial role in developing students' rational, critical, and systematic thinking skills. However, in classroom practice, many students still struggle to understand mathematical concepts, particularly those involving curved-surface three-dimensional shapes such as cylinders, cones, and spheres. These challenges often lead students to make various mistakes when solving problems.

The errors made by students are not only evident in the final answer but can also appear at every step of the problem-solving process. This process includes reading the problem, understanding the problem's intent, translating it into a mathematical model, performing calculations, and presenting the final answer. Therefore, a thorough analysis is needed to identify the nature and causes of these errors so that appropriate solutions can be formulated.

One method that can be used to analyze student errors is Newman Error Analysis (NEA). This method classifies errors into five stages: reading, comprehension, transformation, process skills, and encoding. By applying this method, teachers can identify in greater detail which specific areas are the source of students' errors when solving math problems.

Several previous studies have utilized Newman Error Analysis to examine student errors. The results of a study conducted by Nihadhu Adilah and Nurul Husnah Mustika Sari (2025) indicate that students still make errors at the stages of problem comprehension, transformation, process skills, and final answer encoding when solving problems involving curved-sided three-dimensional shapes. Additionally, research by Pande Made Yuni Rianti, I Made Sugiarta, and I Gede Maysha Succa Darmaputra (2026) revealed that the most

prevalent errors occur during the process skills and final answer writing stages, influenced by students' lack of precision and conceptual understanding.

Nevertheless, these studies were conducted in different contexts and with different subjects, so there is still an opportunity to conduct similar studies in more specific settings. Therefore, further research is needed to obtain a more contextual understanding of students' errors, particularly regarding curved-sided three-dimensional shapes at the junior high school level.

Based on the above discussion, this study aims to analyze students' errors in solving curved-sided three-dimensional shape problems using the Newman Error Analysis approach at SMP Swasta Imelda Medan.

2. Literature Review

2.1. Characteristics and Complexity of Curved Surface Three-Dimensional Shapes

Curved surface three-dimensional shapes, which include cylinders, cones, and spheres, are a branch of geometry that studies 3D objects with curved boundaries. At the Junior High School level, this material possesses a high degree of complexity as it requires students to integrate spatial abstraction with numerical calculations involving the constant π and exponential variables.

Adilah & Sari (2025) emphasize that the characteristics of problems in this field, which are generally presented as contextual word problems, demand strong visualization skills from students. Without a solid conceptual foundation, students struggle to navigate the stage of transforming problems into correct mathematical models. Unresolved difficulties at this stage are often the primary cause of low student learning outcomes in geometry.

2.2. Newman Error Analysis (NEA) Procedure

To map the cognitive obstacles students face in solving problems related to curved surfaces, the *Newman Error Analysis* (NEA) diagnostic method is employed. Newman (1977) argued that mathematical problem-solving involves a hierarchy of interrelated abilities. The following are the five stages of errors identified in this procedure, accompanied by operational examples:

1. Reading: The inability of students to decode symbols, terms, or technical keywords within the problem.
2. *Example:* A student is unable to interpret technical terms such as "diameter," "slant height," or the symbol π (phi), thus failing to initiate the problem-solving process despite being able to read the text aloud.
3. Comprehension: The failure of students to fully grasp the objective of the problem or an inability to identify the "given" and "to find" information.
4. *Example:* A student can read the numbers in the problem but does not understand that a specific value represents the "lateral surface area" rather than the "total surface area," or misunderstands the relationship between the radius and the height of the object.
5. Transformation: The inability of students to determine relevant strategies, mathematical models, or formulas. The student understands what is being asked but fails to select the correct "tool."
6. *Example:* The problem asks for the volume of a cone, but the student utilizes the formula for the volume of a cylinder ($V = \pi r^2 h$) because they failed to transform the information into the correct procedure (e.g., forgetting to multiply by $1/3$).
7. Process Skills: Errors occurring in the calculation steps, algebraic manipulation, or technical computational procedures after the correct formula has been selected.
8. *Example:* The student correctly identifies the formula for the volume of a sphere but makes a mistake when multiplying decimal numbers or errs during the process of cubing the radius (r^3).
9. Encoding: The failure of students to present an accurate final conclusion that aligns with the requested units or context.
10. *Example:* The student calculates the number correctly but forgets to include the unit (e.g., cm^3) or fails to answer the final question (e.g., the problem asks for "painting costs," but the student stops at the "surface area" calculation).

2.3. Synthesis of Prior Research and Relevance of Learning Media

Recent studies provide significant insights into the patterns of student errors in curved surface materials. Research by Rianti et al. (2026) revealed that the majority of Junior High School students face obstacles at the process skills stage, with a percentage reaching 34%. This is generally triggered by a lack of precision in technical arithmetic operations. Similarly, Adilah & Sari (2025) found that errors at the transformation stage are also a major constraint due to weak fundamental conceptual understanding.

As an effort to reduce these error rates, the integration of interactive learning media is highly relevant. The use of Google Sites-based media, such as "BARAYA 9," is designed to help students visualize curved surface objects concretely and dynamically. By strengthening visualization during the comprehension and transformation stages, it is expected that procedural errors at the process skills stage can be minimized, thereby optimizing students' problem-solving accuracy.

3. Research Methode

This study employs a qualitative descriptive approach aimed at providing an in-depth description of students' errors in solving problems involving curved-sided three-dimensional shapes based on the stages of Newman's Error Analysis. This approach was chosen because the study does not focus on testing hypotheses, but rather on detailing the error phenomena experienced by students through test results and interviews.

The research was conducted during the second semester of the 2025/2026 academic year, specifically in April 2026. The research location was Imelda Private Junior High School in Medan, located in the city of Medan, North Sumatra. The selection of this school was based on several considerations: the school had covered the curved-sided three-dimensional shapes curriculum in accordance with the applicable curriculum; the school administration granted permission and provided support for the research; the students possessed heterogeneous academic abilities, allowing for a variety of errors to emerge; and the school's location was easily accessible, enabling the research to be conducted effectively.

Sampling was conducted using purposive sampling, which involves selecting samples based on specific criteria aligned with the research needs. From the total student population, 18 students were selected to represent high, moderate, and low ability levels.

The instruments used in this study included a written test, an interview guide, and documentation. The written test was administered to students in the form of curved-surface geometric problems to identify the types of errors made. The interview guide was used to explore the causes of students' errors in greater depth, while the documentation—consisting of students' answer sheets—served as supporting data in the analysis process.

The research began with a preparation phase that included a literature review on Newman Error Analysis, the development of test instruments and interview guidelines, and obtaining research permission from the school. After the preparation phase was completed, the research proceeded to the implementation phase, which involved administering the test to 18 students, collecting their answers, identifying the errors made, and interviewing the students to determine the causes of their errors. All data was then documented for analysis.



Fig. 1: Post-test questions

The data obtained was analyzed using Newman's Error Analysis, which consists of five types of errors: reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors.

The first stage is reading error. A reading error occurs when a student is unable to read a word, symbol, or important information contained in the problem. This error usually arises because the student is in a hurry, lacks attention to detail, or does not understand the mathematical terms used. For example, a student might misread "radius" as "diameter," or fail to notice that the problem asks for two things at once, such as volume and surface area.

The second stage is comprehension errors. Comprehension errors occur when students can read the problem but fail to grasp its intent or the information provided. At this stage, students actually recognize the words in the problem but fail to identify what is being asked. For example, a student might assume the problem only asks for volume when it actually asks for both volume and surface area, or fail to understand the meaning of the term "surface area."

The third stage is transformation error. A transformation error occurs when students are unable to convert the problem into the appropriate mathematical model or formula. This error typically arises because students cannot identify the formula that matches the shape of the three-dimensional figure in question. For example, a student might use the formula for the volume of a cylinder to solve a problem involving a cone, or write an incomplete formula for surface area.

The fourth stage is process skill error. A process skill error occurs when students perform mathematical procedures or calculations. At this stage, students have actually selected the correct formula but make mistakes during the calculation process. For example, miscalculating multiplication operations, errors in calculating exponents, or errors in calculating fractions.

The fifth stage is encoding errors (errors in writing the answer). Encoding errors occur when students do not write the final answer correctly even though the solution process was correct. These errors can include omitting units, failing to write the final conclusion, or writing a final result that does not match the previous calculation.

Through these five stages, researchers can identify in detail the types of errors students make when solving problems involving curved-sided three-dimensional shapes.

4. Results

Based on the results of the analysis carried out by researchers, almost all students in the class experienced errors when working on description questions on curved-sided geometric figures. The errors that arise are then analyzed using the Newman procedure stages. Details regarding the forms of student errors are presented in Table 1 below.

Table 1: Percentage of Student Errors According to Newman's Theory

Student	Question 1 (Tabung)	Question 2 (Kerucut)	Question 3 (Bola)
S1	Correct	Correct	Correct
S2	Correct	Correct	Correct
S3	Correct	Process Skill	Transformation
S4	Correct	Process Skill	Transformation
S5	Correct	Process Skill	Transformation
S6	Correct	Correct	Process Skill
S7	Correct	Process Skill	Transformation
S8	Correct	Correct	Correct
S9	Correct	Process Skill	Transformation
S10	Correct	Process Skill	Transformation
S11	Correct	Correct	Process Skill
S12	Correct	Process Skill	Transformation
S13	Correct	Correct	Correctar
S14	Correct	Process Skill	Transformation
S15	Correct	Process Skill	Transformation
S16	Correct	Correct	Process Skill
S17	Correct	Process Skill	Transformation
S18	Correct	Process Skill	Transformation

The percentage of each type of error is calculated based on the results of the analysis of student errors discussed previously. Details of these percentages can be seen in Table 2 below.

Table 2: Percentage of Student Errors According to Newman's Theory

Type of Error	Number of Students Making Mistakes in Question Item Number			Total Mistake	Error Percentage (%)
	1	2	3		
Reading Error	-	-	-	0	0
Comprehension Error	-	-	-	0	0
Transformation Error	-	-	11	11	20,3%
Process Skill Error	-	11	3	14	25,9%

Encoding Error

-

-

-

0

0

4.1. Low Ability Students

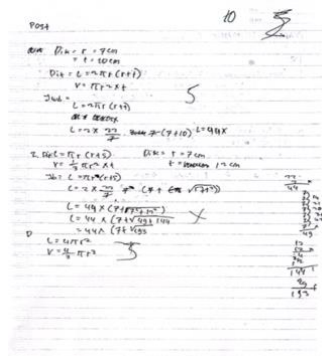


Fig. 2: Low Ability Students' Answers

Figure 2 shows the answers of students with low abilities to the three questions that have been given. From these answers, it can be seen that the majority of students have not been able to solve the questions until they get the correct final result. Apart from analyzing students' work results, researchers also conducted interviews to find out the causes of students' mistakes. The following is a summary of the results of the interview with student 1.

Q: "Do you understand the information contained in question number 1?"

S1: "I know the radius is 7 cm and the height is 10 cm, but I was a bit confused when asked to find the surface area and volume at the same time."

Q: "Do you know the formula that should be used?"

S1: "I remember the formula for the volume of a cylinder, but I'm not sure about the formula for the surface area."

Q: "What information did you get from question number 2?"

S1: "It is known that the radius is 7 cm and the height is 12 cm, then the question is about the volume of the cone."

Q: "Do you know the formula for finding the volume of a cone?"

S1: "I kind of forgot the formula, ma'am. I know there is π and r^2 , but I don't remember whether they are multiplied or divided."

Q: "Can you explain the information contained in question number 3?"

S1: "What I know is that the radius of a ball is 7 cm and I was asked to find its volume and surface area."

Q: "Why don't you complete the calculations to the end?"

S1: "I forgot the formula for the volume of a ball and also the formula for its surface area, so I'm confused about where to start."

Based on the results of the analysis of students' answers to the three questions given, it was found that several students were included in the category of low ability students. This can be seen from the students' inability to complete the questions completely to obtain the correct final answer. From the results of the students' work, it can be seen that some students were only able to write down the information they knew from the problem, but were unable to proceed to the next stage of completion. This condition shows that students still experience difficulties in understanding the problems given and determining the appropriate steps to solve them.

In the first question about cylinders, some students were actually able to identify known information such as the radius and height of a geometric shape. However, some students still experience confusion when asked to determine surface area and volume simultaneously. Errors that appear generally occur at the process skill error stage, namely when students have used the correct formula but made errors in the calculation process. This error causes the final results obtained to be inconsistent with the answer that should be.

In the second question about the volume of a cone, the error that most often appears is an error at the transformation stage (transformation error). Even though students have written down the information they know from the problem correctly, some students cannot determine the correct formula to solve the problem. Some students seemed hesitant to use the cone volume formula, so the solution process was not continued until they got the final answer. This shows that students still do not understand the basic concepts of conic shapes well.

Furthermore, in the third question regarding the ball, students again showed a similar error pattern. Even though students are able to identify the radius of the ball in the problem, most students have difficulty determining the formula for the volume and surface area of a ball. The errors that arise in this problem are generally at the transformation and process skills stages. As a result, students cannot continue the calculation process correctly so that the final answer is not obtained.

Based on the results of this analysis, it can be concluded that students with low abilities tend to experience difficulties at the transformation stage and process skills in solving geometric problems. These difficulties are related to students' inability to choose the right formula and carry out mathematical calculations correctly. Therefore, learning efforts are needed that place more emphasis on understanding concepts and practicing problem solving in stages so that students can improve their ability to solve mathematical problems.

4.2. Medium Ability Students

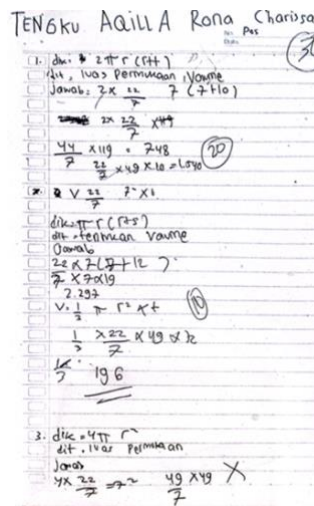


Fig. 3: Answers of Medium Ability Students

Figure 3 shows the results of students' work in the medium ability category on the three curved-sided geometric figures given. Unlike the first student, the second student was able to solve all the questions until he got the final answer. However, there are still several errors in the completion process. To find out the causes of mistakes made by students, researchers not only analyzed the results of students' work, but also conducted interviews with these students.

Q: "Do you understand the information contained in question number 1?"

S2: "Yes ma'am, it is known that the radius of the tube is 7 cm and the height is 10 cm, then what is required is the surface area and volume of the tube."

Q: "Did you experience any difficulties when working on this question?"

S2: "The difficulty is when calculating, because I have to count several steps so I am afraid of making a mistake in the calculation."

Q: "Can you explain what is known and what is asked in question number 2?"

S2: "It is known that the radius of the cone is 7 cm and the height is 12 cm, then what is asked is the volume of the cone."

Q: "What difficulties did you experience?"

S2: "I was a little confused when dividing the calculation result by three, so I wasn't sure about the final result."

Q: "What information did you get from question number 3?"

S2: "It is known that the radius of the ball is 7 cm and we are asked to find the volume and surface area of the ball."

Q: "What difficulties did you experience when working on this question?"

S2: "I actually know the steps, but sometimes I hesitate when calculating so I don't write down the final results completely."

Based on the results of the analysis of students' answers to the three questions given, there are several students who are included in the category of students with moderate abilities. Students in this category are generally able to understand the information contained in the questions and can identify what is known and what is being asked. Apart from that, some students were also able to determine the appropriate formula to solve the given problem. However, several errors were still found in the solution process so that the final answer obtained was not completely correct.

In the first question about cylinders, most students with moderate abilities were able to write down the information they knew and use appropriate formulas to calculate the volume and surface area of the cylinder. This shows that the reading and comprehension stages have been achieved well.

In the second question relating to the volume of a cone, students with moderate abilities are generally able to determine the formula used. However, there are still students who are not careful in carrying out the calculation process, for example when dividing the calculation results by three according to the formula for the volume of a cone. These errors indicate that students are still experiencing problems at the process skills stage, even though the solution steps used are correct.

Furthermore, in the third question about balls, some students were able to identify the information contained in the question and knew the formulas needed to determine the volume and surface area of a ball. However, some students are still hesitant in carrying out calculations so that the solution process is not written down completely or the final results obtained are not accurate. This shows that the errors that occur in students with moderate abilities are generally related to a lack of accuracy in carrying out calculations and writing down the final answer.

Based on the results of this analysis, it can be concluded that students with moderate abilities are able to understand the problems given and determine the appropriate steps to solve them. However, students still experience difficulties at the process skills stage and writing final answers. Therefore, more intensive practice and habituation in solving problems systematically is needed so that students can increase accuracy and precision in solving mathematical problems.

4.3. High Ability Students

Fig. 4: Answers of High Ability Students

Figure 4 shows the work results of students who fall into the high ability category. In this picture, students are asked to answer four questions related to the material of curved geometric shapes. Student 3 was able to solve all the questions correctly, systematically, and get the right final answer without making mistakes. Apart from analyzing the results of students' work, researchers also conducted interviews with these students to find out the difficulties they might experience during the problem solving process.

Q: "Do you understand the information contained in question number 1?"

S3: "Yes, ma'am. It is known that the radius of the tube is 7 cm and the height of the tube is 10 cm. What is required is the surface area and volume of the tube."

Q: "How do you determine the answer?"

S3: "I used the formula for the volume of a cylinder, namely $\pi r^2 t$ and the formula for the surface area of a cylinder, namely $2\pi r(r+t)$, then I entered the known values for the radius and height in the problem."

Q: "What information did you get from question number 2?"

S3: "It is known that the radius of the cone is 7 cm and the height of the cone is 12 cm, then what is asked is the volume of the cone."

Q: "Are you having difficulty with this question?"

S3: "It's not that difficult, ma'am, because the steps are almost the same as the volume of the tube, only multiplied by one third."

Q: "What steps did you take to solve question number 3?"

S3: "I use the formula for the volume of a ball, namely four thirds πr^3 and the surface area of a ball, namely $4\pi r^2$, then enter the radius value into the formula."

Q: "Did you experience difficulty in working on this question?"

S3: "No, ma'am. As long as we know the formula and calculate carefully, the problem can be solved."

Based on the results of the analysis of answers from 18 students, there are several students who fall into the category of high ability students. Students in this category are able to solve the questions given completely and systematically until they get the correct final answer. Apart from that, students can also identify the information contained in the problem correctly and determine the solution steps that are in accordance with the concept of curved sided shapes.

In the first question about cylinders, high ability students were able to write known information such as the radius and height of the cylinder correctly. Next, students can determine the correct formula to calculate the volume and surface area of a cylinder, then carry out calculations systematically until they get the correct final answer. This shows that students have been able to go through the stages of reading, understanding and transforming problems well.

In the second question regarding the volume of a cone, students are also able to determine the correct formula to solve the problem given. Students seem to understand that the volume of a cone is calculated using the formula one third multiplied by $\pi r^2 t$. Apart from that, students can carry out the calculation process carefully so that they get results that match the correct answer. This shows that students do not experience errors at the process skills stage.

Furthermore, in the third question regarding balls, students with high abilities are able to identify known information and determine the correct formula to calculate the volume and surface area of a ball. Students can also complete calculations systematically and write the final answer correctly. This shows that students have been able to go through all stages of problem solving without experiencing significant errors.

Based on the results of this analysis, it can be concluded that high-ability students have a good conceptual understanding of the curved-sided geometric material. Students are able to identify the information contained in the question, determine the correct formula, and carry out calculations carefully to obtain the correct final answer. Thus, high ability students do not show any significant errors at the error analysis stage according to Newman.

5. Conclusion

This study reveals that the errors made by students when solving problems involving curved-sided three-dimensional shapes were predominantly process-skill errors (25.9%) and transformation errors (20.3%), while errors in the reading, comprehension, and encoding stages were not detected. These results reinforce the view that students' main challenges relate to selecting the correct formula and accuracy in calculations, rather than understanding the problem.

Furthermore, distinct error patterns emerged based on students' ability levels: students with low ability struggled during the transformation and process stages; those with moderate ability were more likely to make calculation errors; whereas students with high ability could solve the problems without significant errors.

Therefore, these findings highlight the importance of a learning approach that systematically focuses on strengthening conceptual understanding and procedural skills to reduce students' errors in solving mathematical problems.

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