Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.15, No.5, 2024

Analysis of Student Mistakes in Solving Contextual Problems Building Material with Curved Sides (Tube) Based on Kastolan Stages

Afifah Nurhasanah Salsabila Khairunnisa Putri Fasya Rivan Septian Neneng Aminah* Fuad Nasir
Department of mathematics education, Faculty of Education and science, Swadaya Gunung Jati University
Cirebon, West Java, Indonesia
E-mail of the Corresponding author: nenengaminah@ugj.ac.id

Abstract
This research aims to find out the mistakes made by students in problems with math subjects about curved side shapes in tube shapes. This research is qualitative research with qualitative data analysis techniques. The subjects in this research were students at Junior High 10th, Cirebon, class 9A with a total of 22 students. Research conducted on students at Junior High 10th, Cirebon to found out the errors that are made by students in solving questions on curved sided geometric material related to the volume and surface area of cylinders, namely conceptual errors, procedural errors and technical errors (according to the Kastolan error stages). Which states that the causes of mistakes that students often make are because students do not understand the questions well, do not master the material, do not know the steps to solve the questions, aren't careful in working on the questions, and do not write conclusions
Keywords: Error analysis, Geometry, Tube, Kastolan theory
DOI: 10.7176/JEP/15-5-01
Publication date: April 30th 2024

1. Introduction

Evaluation of the learning process, also known as student evaluation, and that's very important to find out whether the learning system used by the teacher is effective or not. Learning evaluation is also carried out with the aim of determining follow-up to the assessment. There are many ways to assess students' abilities, such as looking at their mistakes when solving the problems.

Student's difficulties and errors are most often experienced in solving contextual problems, that're prove students' low critical thinking skills in solving mathematical contextual problems. Actually, mistakes are a normal thing for students (Afdila & Roza, 2018). However, if there's many continuous errors in the same problems, special treatment is needed. Because if special treatment is not immediately given, it will have a bad impact for students.

Factors that cause students to make mistakes in solving contextual problems include the problem that's not being in accordance with the students' abilities regarding the material presented by the teacher and students being slower to digest the concepts given by the teacher (Afdila & Roza, 2018). Apart from this problem, another problem is about students' habits when working on mathematics problems with the same form of example questions as those given by the teacher. This results in students having difficulty working on non-routine questions such as story problems.

The problem that students faced is the difficulty in answering questions on curved sided geometric shapes and one of the sub-materials taught in curved sided shapes is cylinders. A cylinder is a geometric shape bounded by two congruent and parallel sides in the form of a circle and one curved side, the base plane and the top plane of the circle with the same radius and height (Wulandari & Anugraheni, 2021).

Based on these problems, it's necessary to research the mistakes that's made by students to avoid making the same mistakes when solving surface area and volume on curved side shapes in cylindrical shapes. Student errors in solving questions can be explained by looking at the results of the explanation, so that later the type of error can be identified.

Kastolan's theory includes three types of student errors in solving problems: conceptual, procedural, and technical errors. Kastolan's theory adheres to a hierarchical style in analyzing student errors, meaning that the analysis must be ordered from the first, namely conceptual errors, procedural errors and technical errors. In this research, the Kastolan theory is used as a reference for error analysis. Kastolan analysis is a method that is used to see the mistakes students make when solving math problems. Kastolan theory adheres to a hierarchical style in analyzing student errors, meaning the first analysis, namely conceptual errors, procedural errors and technical errors (Dewi et al., 2021).

Kastolan theory can be used as an alternative to analyze errors in answering mathematical questions (Fajriyati Afdila, 2018). Kastolan theory errors are divided into three types, namely conceptual errors, procedural errors, and technical errors. While technical errors are errors that occur during the calculation process used to

solve problems, conceptual errors consist of errors in interpreting concepts, errors in determining the problem solving formula, or errors in using formulas that do not meet the completion requirements (Ayuningsih et al., 2020).

Research related to error analysis in answering cartesian coordinates questions using Kastolan theory, revealing that 54.5% of students made conceptual errors, 27.3% of students made procedural errors, and 18.2% made procedural errors. technical problem (Fitriyah et al., 2020). The same thing was also done by (Sari & Najwa, 2021)who stated that the things that cause errors are students' lack of knowledge of the material and lack of attention to the material presented. Meanwhile, this research intends to analyze students' errors in solving circular mathematical problems based on kastolan theory.

The aim of this research is to analyze and describe the types of student errors in completing contextual problem solving on surface area and volume of curved sided shapes based on the Kastolan stages, in class 9A students at Junior High 10th, Cirebon. The benefit of this research is one form of effort to improve students' abilities in studying mathematics, especially in solving contextual problems regarding the surface area and volume of curved sided shapes in terms of analysis of student errors in solving contextual problems with curved sided shapes related to the volume and surface area of cylinders.

2. Research Methods

The method of this research is using qualitative descriptive research that examines the errors made by students in solving surface area and volume problems on curved side shapes in cylindrical shapes. Regarding this analysis method, Ridwan, M (2021) explains that the qualitative descriptive method is a method that contains an analysis process, description and summary of various conditions taken from a collection of information originating from direct observations and interview results in the field of the problem being researched. According to (Uin & Banjarmasin, 2018) analysis is a qualitative data analysis activity with data collection, data reduction, data presentation and conclusion of research results.

The subjects of this research are students in class 9A of Junior High 10th, Cirebon, totaling 22 students with the sampling technique are purposive sampling. According to (Aminah et al., 2022) purposive sampling is a data sampling technique with certain considerations. The error analysis used in this research uses the Kastolan error stages. These indicators are presented in table 1 below:

Tabel 1. Kastolan Error Indicator

No	Error Type	Error Indicator
1	Conceptual Error	1. Students made mistakes in determining formulas, theorems or definitions to answer a problem 2. Use of formulas, theorems, or definitions that are not in accordance with the prerequisite conditions for the application of the formula, theorem, or definition. 3. Do not write formulas, theorems or definitions to answer a problem.
2	Procedural Error	1. Students make mistakes in solving problems. 2. Students' errors or inability to manipulate steps to answer a problem. 3. After determining the final result of the calculation process, students do not write down International Units. Because writing International Units and symbols in a formula is a necessity in writing.
3	Engineering Error	1. Students make mistakes in the process of calculating the results of these questions.

The data collection technique that's used in this research is, (1) Tests, given to obtain data, namely the results of student work. The questions given consist of 3 contextual questions related to the math chapter about curved sided shapes (tubes). The results of the student's work were then analyzed using the kastolan error stage analysis. (2) Interviews, conducted to determine students' understanding of the questions and answers to strengthen the data results from the written test. (3) Documentation, documenting the results of student answers and collecting student data and grades.

3. FINDINGS AND DISCUSSION

This research was carried out in the second semester on class 9A students at Junior High 10th, Cirebon. This research was carried out by conducting tests on students regarding description questions about curved sided shapes related to the volume and surface area of a tube. Next, an interview was conducted with the students by giving the students a questionnaire. Conducting interviews using a questionnaire method aims to save time during research. The number of students in this research was 30 students and the description questions used in this research were 3 contextual problem questions related to the volume and surface area of the tube.

3.1 Findings

3.1.1 Student Test Results

The results of the trial questions regarding the description of the geometric material on the curved side of the tube are related to the volume and surface area. All students have tried to answer these questions, however there were still a lot of students who still made mistakes. That's why it's necessary to analyze student errors using Kastolan theory.

The description questions used in this research are curved-sided geometric figures related to the volume and surface area of a cylinder which consist of 3 description questions as follows:

1. A tub of water in the form of a tube, has a diameter of 100 cm and height 160 cm. Within an hour it had filled a quarter of its total volume. The amount of water needed to fill the empty part of the water tub is... cm^3.
2. A cylinder has a 39,250 $cm^3$of volume and the length of the base on the tube is 25 cm. How is the tube's height?
3. A pipe paralon has a base radius of 7 cm, while the height of the tube is 20 cm. Calculate the surface area of the pipe!

Figure 1. Question about description of curved sided geometric figures, related to the volume and surface area of the tube

From the three questions given to the students, data was obtained in the form of the students' answers to the questions given. The students' answers or written test results are analyzed to identify the types of students' errors in working on the questions. Questions are analyzed based on Kastolan stages which are based on error indicators. The forms of student errors found in the results of written tests on contextual problems regarding curved-sided geometric shapes related to the volume and surface area of cylinders can be seen in the table of the average percentage of students who made errors based on the following Kastolan stages:

Table 2. Average percentage of students who make mistakes based on Kastolan stages

NO	INDICATOR	QUESTION NUMBER		
		1	2	3
1	Conceptual Error	100%	18,18%	100%
2	Procedural Error	27,27%	59,09%	9,09%
3	Engineering Error	54,54%	4,54%	13,63%

Table 2 shows that all students made conceptual errors in question number 1 and question number 3. This happened because students did not understand the meaning of question number 1 and question number 3. Meanwhile, the conceptual errors made by students in question number 2 were quite low, namely there were 4 students or 18.18%, which means that almost all students can understand the meaning of question number 2, and students can determine using the formula to find the height of the tube.

Many procedural errors made by students occurred in question number 2. There were 13 students or 59.09% of students who made procedural errors in solving contextual problems in question number 2. Procedural errors that often occurred were students forgetting to write international units in the final result or student answers.

Many technical errors made by students occurred in question number 1. There were 12 students or 54.54% of students who made technical errors in solving contextual problems in question number 1. The technical error that often occurred was that students were unable to calculate ¾ of the volume of a cylinder.

The following sentence is a discussion of the mistakes made by class 9A students Junior High 10th, Cirebon in solving curved-sided geometric figures related to the volume and surface area of the cylinder.

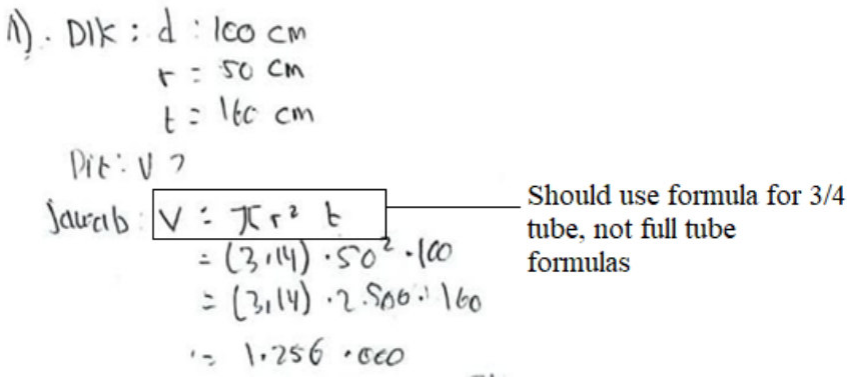

Figure 2. Student A's mistake in question number 1

In the 2nd picture, student A and other students made conceptual errors, technical errors and procedural errors as shown in the picture. The conceptual error that A made was the wrong formula for solving the contextual problem in question number 1. When solving this question, students should have used the formula ¾ of the volume of a cylinder because in the question it was explained that the water tub was already filled with a quarter of its total volume.

The next is the technical error that student A made, namely a mistake in the process of calculating volume of the tube. The procedural error that student A and other students made was that they did not write the units in the results of calculating the volume of the cylinder. Student A and other students should have written the units as centimeter³(cm³) after getting the results.

The results of this analysis can be concluded that the errors occurred because students were not able to understand the material on cylinder volume so that student A was not correct in determining the formula and was less careful.

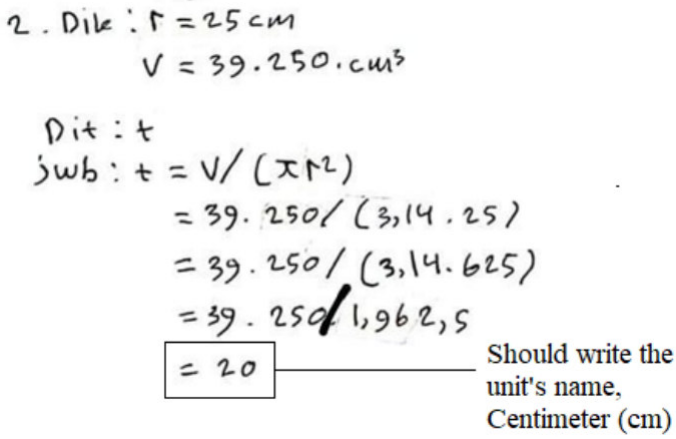

Figure 3. Student B's error' for question number 2

In the 3rd picture, student B made a procedural error as in the picture above. The procedural error that student B made was not explaining the units in the final result of the calculation process to find the high value on the tube. Student B should write the units in centimeters after finding height value on the tube. The results of this analysis can be concluded that the mistakes made by student B occurred because the students were not careful in solving contextual problems regarding the volume of cylinders.

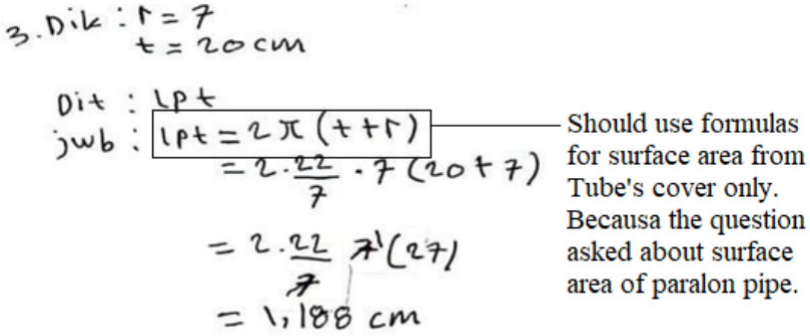

Figure 4. Student C's error' for question number 3

In the 4th picture, student C and almost all students in class 9A Junior High 10th, Cirebon made conceptual errors, namely not being able to understand the meaning of the questions being worked on and not being precise in determining the formula that should be used. Student C and all other students should only need to find the surface area of the cylinder, because the question is asked to find the surface area of the pipe paralon. Meanwhile, we know that paralon pipes do not have a tube base and lid. From the results of this analysis, it can be concluded that the errors that occurred were due to students not understanding the material on the surface area of tubes and student C not being able to illustrate objects in everyday life using the formula for the surface area of tubes.

3.1.2 Student's Recapitulation

This response questionnaire was administered to all students, totaling 22 respondents. Discussion of the questionnaire results with 3 indicators for each question is presented in the following table.

Table 3. Recapitulation of Student Response Questionnaire

No	Question	Yes	No
1	Can you understand the question in question No. 1?	18,19%	81,81%
2	Do you have difficulty determining the formula in question No. 1?	95,46%	45,45%
3	Did you encounter difficulties in solving question No. 1?	86,37%	13,63%
4	Can you understand the question in question No. 2?	27,28%	72,72%
5	Do you encounter difficulties in determining the formula in question No. 2?	72,72%	27,28%
6	Did you encounter difficulties in solving question No. 2?	72,72%	27,28%
7	Can you understand the question in question No. 3?	27,28%	72,72%
8	Do you have difficulty determining the formula in question No. 3?	81,81%	18,19%
9	Did you encounter difficulties in solving question No. 3?	81,81%	18,19%

Table 3 above explains that there are 81.81% of students who do not understand question number 1. And almost all students experienced difficulty in determining the formula in question number 1. There were 95.46% of students who experienced difficulty in determining the formula to solve the problem in question number 1. There were 86.37 % of students who experienced difficulty in solving question number 1.

There were 72.72% of students who did not understand question number 2. It was considered standard and almost some students had difficulty in determining the formula in question number 2. There were 72.72% of students who had difficulty in determining the formula to solve the problem in question number 2 and some students had difficulty in solving question number 2. There were 72.72% students who experienced difficulty in solving question number 2.

There were 72.72% of students who did not understand question number 3. It was considered standard. There is still a high number of students who experience difficulty in determining the formula in question number 3. There are 81.81% of students who experience difficulty in determining the formula to solve the problem in question number 3 and there are still high numbers of students who experience difficulty in solving question number 3. There are 81 .81% of students experienced difficulty in solving question number 3.

3.2 Discussion

Based on the explanation above, many of the mistakes made by students are conceptual errors and technical errors. This error is caused by students not being able to determine the formula and write down each step in solving it in detail, resulting in errors in the next steps, apart from that in calculations and in determining what steps will be used to solve the contextual problem in the question. This is in line with research conducted by (Susanti & Taufik, 2019). Which states that the causes of mistakes that students often make are because students do not understand the questions well, do not master the material, do not know the steps to solve the questions, aren't careful in working on the questions, and do not write conclusions.

Some students may not understand the mathematical concepts underlying cylindrical shapes, such as volume and surface area formulas. This lack of understanding can confuse them about how to apply these concepts in the context of the problem. Students' difficulties in working on questions are caused by various factors, both internal and external factors (Jamal (2014) in the journal (Ulfa & Kartini, 2021). Internal factors can be a lack of motivation, students' lack of interest in the material, students' lack of talent in mathematics, students' mindsets that think mathematics is difficult, and so on (Raharti & Yunianta, 2020). External factors are usually the conditions of the learning environment, lazy friends, family support, and others (Layn & Kahar (2017) in the journal (Ulfa & Kartini, 2021).

Students may make technical errors in calculations and use incorrect formulas, such as errors in calculating the volume and surface area of a cylinder. This can happen due to lack of attention to the questions or lack of patience in solving the questions carefully. From this it can be said that understanding concepts is important for learning mathematics meaningfully, of course, teachers hope that the understanding achieved by students is not limited to understanding that can connect (Murizal (2012) in the journal (Ulfa & Kartini, 2021).

For some students, it is difficult to visualize the shape of a tube in their minds. Without good visualization skills, they may have difficulty understanding how the shape and properties of the tube can influence solving problems. Based on the results of research conducted by Kusniati (2011) in (Sholihah & Afriansyah, 2018), it is known that: "Achievement of the level of development of geometric thinking according to Van Hiele's theory of 38 children, 28 children were at level 0 (visualization), 9 child is at level 1 (analysis), and 1 child is at the informal deduction level. The type of error most often made by research subjects is conceptual error. This is due to a lack of understanding of the concept. "So, to reduce the number of conceptual errors made by students in the material, it is necessary to consider the students' abilities and knowledge in providing the material and emphasize learning on understanding concepts."

Lack of practice in working on cylinder geometric problems can also cause students to be less skilled in applying relevant mathematical concepts. With sufficient practice, it can help students strengthen their

understanding and skills in solving these questions. However, students tend to do negative things such as cheating to overcome these problems. Honesty in learning should be in the spotlight in the field of education to achieve maximum student ability analysis results. The reason students cheat is because the material they studied was not tested in the exam, they didn't study hard so they didn't know the answer, or they just wanted to check the answer because they weren't sure about the answer themselves (In'am & Sutrisno, 2021).

Mistakes that students make in solving questions can be analyzed by looking at the results of students' answers, so that we can find out what types of errors students made. In this case, the Kastolan theory is the reference. If the error is not corrected, subsequent errors will continue to occur. So, to avoid students making mistakes continuously, analysis of the errors that occur is very necessary to improve them in the future.

4. CONCLUSION AND RECOMMENDATION

Based on the results of research conducted on class 9A students at Junior High 10th, Cirebon, it was found that errors were made by students in solving questions about curved-sided geometric shapes related to the volume and surface area of tubes, namely conceptual errors, procedural errors and technical errors (according to stages Kastolan error).

Conceptual errors made by students are due to students not understanding the material on curved sided shapes, specifically tube shapes, students making mistakes in determining the formula to use, and students not being used to solving contextual problems. The procedural error that students make is not being careful in writing the units in the final results. As well as technical errors made by students in the process of calculating the volume of the tube.

From these results it can be concluded that student errors are very diverse, with the factors causing errors made by students in solving problems on the subject of surface area and volume of curved sided shapes including: a). Students who do not understand the material on curved sided geometric figures. b). Students who do not read carefully and understand the meaning of the questions well. c). Students are not careful in working on questions. d). Students are not used to working on story problems or contextual problems.

The solution to reduce mistakes that's made by students is by giving them non-routine questions such as story questions with contextual problems and repeating the understanding of the concept of curved-sided geometric figures, especially on the volume and surface area of cylinders. So the students have the skill in solving the questions given.

5. ACKNOWLEDGEMENT

The authors would like to Thanks our University, Swadaya Gunung Jati Cirebon for providing moral support, and also Thanks to Junior High 10th Cirebon for the opportunity to conduct our research in there. Finally, the authors hopes that this article can be useful for all parties and people who need this as their references. May the good deeds have been given will be rewarded by Allah SWT.

References

Afdila, N. F., & Roza, Y. (2018). Analysis Of Student Mistakes In Solving Contextual Problems With Flat Side Building Materials Based On Kastolan Stages. *LEMMA : Letters Of Mathematics Education*, *5*(1), 65–72.

Aminah, N., Sukestiyarno, Y. L., Wardono, W., & Cahyono, A. N. (2022). Computational Thinking Process Of Prospective Mathematics Teacher In Solving Diophantine Linear Equation Problems. *European Journal Of Educational Research*, *11*(3), 1495–1507. Https://Doi.Org/10.12973/Eu-Jer.11.3.1495

Ayuningsih, R., Dwi Setyowati, R., Esti Utami, R., & PGRI Semarang, U. (2020). *Imajiner:* Journal Of Mathematics And Mathematics Education Analysis Of Student Errors In Solving Linear Program Problems Based On Kastolan Error Theory. *2*(6), 510–518.

Dewi, E. K., Nizaruddin, N., & Pramasdyahsari, A. S. (2021). Analysis Of Student Errors In Solving Spldv Questions Based On Castolan Stages Reviewed From Students'cognitive Style. *International Journal Of Research In Education*, *1*(2), 110–120.

Fajriyati Afdila, N. (2018). Analysis Of Student Mistakes In Solving Contextual Problems With Flat Side Building Materials Based On Kastolan Stages. *Jurnal LEMMA*, *5*(1). Https://Doi.Org/10.22202/Jl.2018.V5i1.3383

Fitriyah, I. M., Pristiwati, L. E., Sa'adah, R. Q., Nikmarocha, N., & Yanti, A. W. (2020). Analysis Of Student Errors In Solving Cartesian Coordinate Story Problems According To Kastolan Theory. *Al-Khwarizmi:* Journal Of Mathematics And Natural Sciences Education, *8*(2), 109–122.

In'am, A., & Sutrisno, E. S. (2021). Strengthening Students' Self-Efficacy And Motivation In Learning Mathematics Through The Cooperative Learning Model. *International Journal Of Instruction*, *14*(1), 395–410.

Sari, R. A., & Najwa, W. A. (2021). Analysis Of Student Errors In Completing Integer Addition Based On Kastolan Theory. *Jurnal Sekolah Dasar*, *6*(1), 77–83.

Sholihah, S. Z., & Afriansyah, E. A. (2018). Analysis Of Students' Difficulties In The Process Of Solving Geometric Problems Based On Van Hiele's Stages Of Thinking. *Mosharafa: Journal* Mathematics Education, *6*(2). Https://Doi.Org/10.31980/Mosharafa.V6i2.317

Susanti, R. D., & Taufik, M. (2019). Analysis Student Mistake Of Teacher Professional Education In Completing Story Problems Based On Newman Procedures. *International Journal Of Trends In Mathematics Education Research*, *2*(2), 72–75. Https://Doi.Org/10.33122/Ijtmer.V2i2.59

Uin, A. R., & Banjarmasin, A. (2018). *Qualitative Data Analysis*(Vol. 17, Issue 33).

Ulfa, D., & Kartini, K. (2021). Analysis Of Student Errors In Solving Logarithm Problems Using The Kastolan Error Stages. *05*(01), 542–550.

Wulandari, I. M., & Anugraheni, I. (2021). Development Of Visual-Based Mathematical Comic Media On Cone And Tube Material In Elementary Schools. *Wahana Pendidikan Scientific Journal*, *7*(2), 269–277.