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Decoding Student Struggles in Geometry: Newman Error Analysis of Higher-Order Thinking Skills

Nia Kania[1*], Yaya S. Kusumah[2], Jarnawi Afgani Dahlan[3], Elah Nurlaelah[4], Florence Kyaruzi[5]

[1]Universitas Majalengka, Majalengka Jawa Barat, Indonesia
[2,3,4]Universitas Pendidikan Indonesia, Bandung Jawa Barat, Indonesia
[5]University of Dar es Salaam, Dar es Salaam, Tanzania

*Corresponding author: niakania@unma.ac.id

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Abstract

Maths is one of the perceived challenging courses for many pupils. This study employs a qualitative research approach to examine students' challenges when solving mathematical Geometry issues. This qualitative study was conducted in a Majalengka, West Java, junior high. Five randomly selected kids with different math skills participated. Following up with interviews and testing Bloom's taxonomy's latest HOTS signal questions were the critical data collection approaches. These questions test analytical (C4), evaluative (C5), and creative (C6) skills. Students had to model, sketch, confirm geometric calculations, and calculate dimensions using available components. Newman's Error Analysis was applied to analyse typical misunderstandings and errors. This exercise showed students' geometric reasoning and problem-solving weaknesses. The findings suggest customised teaching methods to improve students' geometric knowledge and performance. The findings helped us comprehend pupils' cognitive processes and geometric challenges.

Keywords: Geometry; Higher-order thinking skill; Newman error analysis.

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1. Introduction

Mathematics is often considered one of the most challenging subjects by many students. When it comes to schoolwork, mathematics is generally considered to be the most challenging subject for a significant number of students. Mathematics addresses a great variety of abstract concepts that makes it a challenging subject if not well taught through interactive approaches (Hanan & Alim, 2023). Some examples of abstract concepts include infinite series, spaces with more dimensions than two, and real numbers. Pupils may have difficulty comprehending mathematics because it demands thinking outside the realm of physical objects and processes (Boaler, 2016).

There is also the possibility that the hierarchical structure of mathematics is somewhat responsible for the apparent difficulty. Because mathematics is an accumulative science, new concepts in mathematics are constructed on top of discoveries made in the past. According to Hiebert and Lefevre (1986), students may perceive that they are falling behind intellectually in mathematics if they cannot progress to more sophisticated courses because they have difficulty comprehending fundamental concepts related to mathematics. The subject is perceived complicated for several reasons, one of the most important being the mathematical requirement for exactness and precision. The computations and reasoning involved in mathematics require higher precision than those involved in other fields that allow approximation. As a result of the high level of precision necessary in mathematics, Schoenfeld (1988) contends that pupils may sense anxiety and fear of making mistakes. This may cause them to feel even more frustrated by the challenges associated with the subject.

Teaching mathematics in many schools is significantly impacted by traditional approaches, which can affect students' perspectives and attitudes regarding the subject. Boilers' (2008) research demonstrates that emphasising memorisation, repetitive methods, and speed in mathematics instruction might impede students' grasp of concepts and problem-solving abilities, resulting in less engagement and motivation. Students may find geometry challenging for several reasons, including the numerous problems in scientific literature. Geometric notions are theoretical, and it is possible that they do not immediately relate to difficulties encountered in the real world. (Komalasari et al., 2021). The fact that this is the case is one of the reasons why geometry can be so complex to comprehend at particular times. Many external elements can make it challenging for students to comprehend three-dimensional geometric concepts. (Novita et al., 2018).

As stated by Fajriadi et al. (2022), one further issue that may add to the difficulties that students are experiencing with geometry is the fact that they already possess an understanding of the subject from earlier grades. According to the notion put forth by Van Hiele (Pungkasari & Purwosetiyono, 2020), individuals who lack the spatial awareness skills necessary to solve geometric problems may find it challenging to comprehend the concept of geometry. This is because these abilities are essential for addressing problems involving geometry. According to Nurhakim et al. (2023), the hierarchical structure of mathematics makes things even more difficult for students who do not have a solid understanding of the fundamental concepts that serve as the foundation for geometry. In addition, students may have difficulty comprehending geometric concepts when focusing on precision and accuracy rather than conceptual understanding or when exposed to standard teaching methods that prioritise memorisation more than conceptual understanding. (Hanan & Alim, 2023).

In the initial level, one of the most critical components is the analysis of youngsters' difficulties with their arithmetic assignments. This difficulty analysis aims to identify and investigate the many mathematical problems students have trouble with. The results of this study of obstacles will not only demonstrate the most common problems that students face but also provide valuable information that can be used to determine the solutions that need to be implemented.

The phrase Newman Error Analysis (NEA) refers to the process of identifying and gaining an understanding of the difficulties that youngsters face. Numerical error analysis, also known as NEA, is a valuable tool that may be used to investigate the numerous modes of error that students make when attempting to solve mathematical problems. (Putri & Hastari, 2022). Panjaitan and Irawati (2018) say that the NEA framework is meant to find a wide range of learner flaws in a planned way. This group has mistakes concerning reading, understanding, process skills, and learning. Learning failures can be broken down into a few different types. Researchers have shown that NEA can help them learn more about the different types of mistakes students make, why they make them, and how gender, visual intelligence, memory skills, and math skills are just a few of the things that can affect these mistakes. It has been noted that NEA can help researchers better understand these kinds of mistakes (Mukminah & Riana, 2020; Putri et al., 2023; Putri & Andriani, 2023).

In addition, the NEA has played a vital role in leading attempts to look into specific math mistakes (Napsawati et al., 2023; Oktafia et al., 2020; Takaendengan et al., 2022). Some areas include power series convergence, exponential numbers, fundamental analysis, time dilation, and operation research. This method was used to check things out. A student's competency in problem-solving by applying appropriate mathematical computations or processes can be evaluated by how well they employ process skills. Students are evaluated based on their ability to compose responses that are structured and founded on reliable information through the encoding process. Educators and teachers are in a better position to assist their students in overcoming these hurdles if they are knowledgeable about the many types of errors that students make when attempting to solve mathematical issues.

2. Methods

This study employs a qualitative research approach to examine students' challenges when solving mathematical issues. The research participants comprised five students in the eighth grade of a junior high school in Majaelengka district, West Java. They were selected using purposive sampling, which involves selecting data sources based on specific considerations. When selecting subjects, it is important to consider individuals with knowledge of flat-sided geometric shapes and students with high, moderate, and low mathematical abilities.

The data-gathering methodology employed in this research involved administering test questions and conducting participant interviews. The test questions are formulated using higher-order thinking skill (HOTS) indications derived from the revised Bloom's taxonomy. Presented below is the grid:

Table 1 - Question Indicators for Student Difficulty

HOTS Dimensions	Question Indicator	Question
Analysis (C4)	Students must verify the accuracy of an answer to a problem involving a beam's surface area, where the edges' lengths are known.	1
Evaluation (C5)	By knowing the surface area of an incomplete rectangular pyramid, students may determine other dimensions' measurements.	3
	Students can determine the larger volume between the two block pictures.	5
Create (C6)	Students can illustrate a diagram of a right-angled prism with dimensions that correspond to the provided volume.	2
	Students can create a house by combining a cube and a rectangle pyramid, with the volume of the pyramid already known and its base being the same size as the cube.	4

Furthermore, to enhance the depth of students' responses. A post-test interview was done with the subjects after they had finished answering the exam questions. Data analysis encompassed data reduction, data display, and conclusion.

3. Results and Discussion

3.1. Results

There were a five-question test for twenty-five students who have been learning about flat-sided geometric shapes. The goal is to capture an image representing the students' understanding level. Each question aims to test several talents, such as recognising forms, calculating volumes, and solving complex problems. Discussions about mistakes often make use of the answer key as a reference. NEA is employed to analyse the test data and determine the different types of student errors. The parameters used to pick interview topics are based on students who demonstrate very high difficulty levels when answering questions on written exams.

3.1.1. Question Number 1

In order to resolve this issue, students must possess a fundamental comprehension of the fundamental principles and the ability to compute the surface area of a beam. Subsequently, students analyse by juxtaposing the outcomes of their computations with the responses provided by the entities mentioned in the question (Andi/Odi). Question number 1 is designed to assess student challenges.

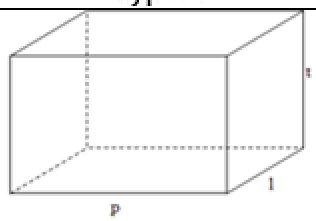
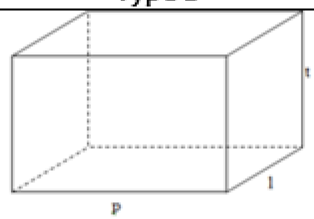
Type A	Type B
 Look at the block image above. The beam has length, width and height, respectively, 15 cm, 5 cm and 11 cm. Calculate the surface area!	 Look at the block image above. The beam has length, width and height of 17 cm, 6 cm and 12 cm. Calculate the surface area!
This question is homework that Andi must do. According to Andi, the surface area of the block is 690 cm2. In your opinion, is Andi's answer correct? Explain your reasons!	This question is homework that Odi must do. According to Odi, the surface area of the block is 690 cm2. In your opinion, is Odi's answer correct? Explain your reasons!

Figure 1 Question number 1 to analyse student difficulties

Question number 2 requires students to compare their answers and the answers provided in the question. Students must be able to analyse mistakes that characters might make in the questions or mistakes in the student's answers. Even though it is not directly visible, solving this problem requires analytical skills to evaluate the answers given by other people. The following is one of the students' answers:

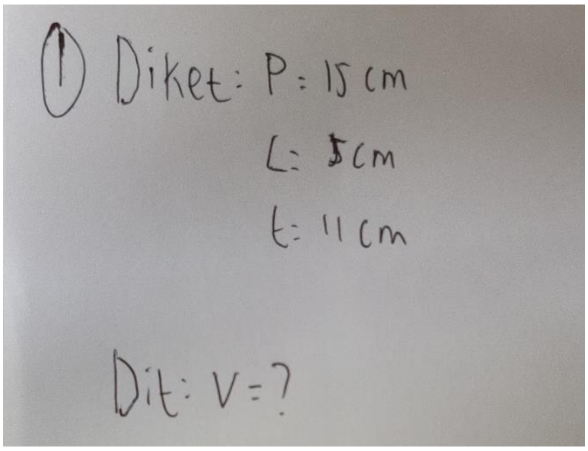


Figure 2 Student Answer Sheet for Question Number 1

In general, students could read this question well. This indicates that students have good reading skills. Students' answers that can write down what is known and what is stated illustrate that students have good comprehension. Meanwhile, transformation errors reflect students' difficulties converting verbal or visual information into mathematical equations. This can indicate that a student cannot apply mathematical procedures correctly through the use of process skills errors, where students cannot use the formula for the surface area of a block correctly, namely $2(pl + pt + lt)$, so, of course, they cannot use process skills. done well, namely calculating the Surface Area = $2 \times ((15 \times 5) + (15 \times 11) + (5 \times 11)) = 590$ square centimetres. This results in students not being able to encode correctly. Students should be able to write down the answer, which should be 590 square centimetres, so they can decide that Andi/Dina's answer is wrong. The following is the overall student answer score for question number 1:

Table 2 - Student answer score for question number 1

	Score	f	%
Question Number 1	5	-	-
	4	-	-
	3	-	-
	2	9	36
	1	16	64
	0	-	-

According to the data in Table 4.2, 36% of students responded with a score of 2, while the remaining 64% responded with a score of 1. Consequently, none of the pupils could convert their knowledge into mathematical formulas and enquire about it. Consequently, pupils cannot accurately express their understanding and enquiries using mathematical terminology. Students' basic mathematical knowledge impacts their ability to comprehend intricate mathematical topics (Kania et al., 2023). Furthermore, conventional evaluation techniques, characterised by brief and organised questions, do not effectively measure durable problem-solving skills.

Through interviews conducted with five students, it was determined that the areas in which students struggled the most were basic geometric ideas and the ability to visualise. Although this course involves two-dimensional depictions, many students struggle mentally to visualise three-dimensional forms. When confronted with mathematical tasks, some other students voiced their apprehensions over their lack of self-assurance and tendency to be indecisive.

3.1.2. Question Number 2

Question number 2 illustrates that students must have a basic understanding of the concept of the volume of a right-angled triangular prism, namely V= base area × height of the prism, where the base is the area of the base of a right-angled triangle: 1/2 × base × height of the triangle. Next, students are required to be able to create a drawing correctly based on the nature and characteristics of the requested flat-sided shapes. The following is question number 2, which is used to analyse student difficulties:

Type A	Type B
Andi had difficulty doing the assignments given by the teacher at his school. Pay attention to Andi's assignment below! "Draw a right triangular prism that has a volume of 240 cubic centimetres."	Dinda had difficulty doing the assignments given by the teacher at his school. Pay attention to Dinda's assignment below! "Draw a right triangular prism that has a volume of 240 cubic centimetres."

Figure 3 Question number 2 to analyse student difficulties

Figure 3 illustrates that students must have a basic understanding of the volume of a right-angled triangular prism. Next, students must be able to analyse the information provided and appropriately evaluate various combinations of numbers when the volume is determined. Solving this problem is more critical in analytical and evaluation skills and applying the basic concept of volume in drawing an appropriate prism. The following is one of the students' answers:

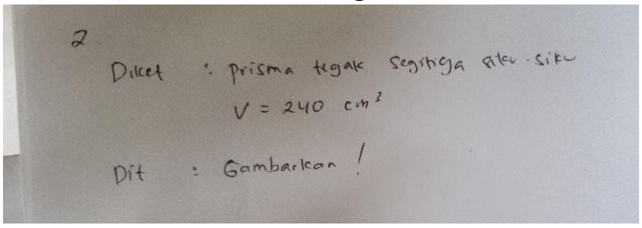


Figure 4 Student Answer Sheet for Question Number 2

Overall, the students demonstrated proficiency in accurately comprehending the problem and correctly identifying the task of describing a right-angled triangular prism. This suggests that students possess proficient reading abilities. Students' ability to accurately record factual information and explicitly articulated details demonstrates their strong comprehension skills. At this point, students must precisely describe a prism with a designated volume. Nevertheless, during the transition phase, students encounter obstacles that hinder their progress to the subsequent stage. During the process skills stage, students may lack knowledge or certainty regarding the formula for calculating the volume of a right-angled triangular prism: Volume = area of the base multiplied by the height of the prism.

If pupils cannot convert problems into formal mathematical form, they will undoubtedly be unable to apply processes or formulas accurately. In this scenario, pupils cannot accurately ascertain the prism's dimensions (namely, the base area and height) when the volume is already known. A right-angled triangular prism has a base as a right triangle. The base area is calculated using the formula 1/2 times the product of the lengths of the two sides that form the right angle. Firstly, the height (*h*) of the prism can be determined, simplifying the determination of other dimensions. For instance, in a prism with *a* volume of 240 cubic centimetres, if we select *h* = 10 cm, we can calculate the base area using the equation 240 = Base area × 10. Therefore, the base area equals $= \frac{240}{10} = 24$ square centimetres. Once the area of the base is determined to be 24 square centimetres, students can calculate the lengths of the sides of the right triangle that make up the base. This can be done using the formula $= \frac{1}{2} \times a \times t$ = 24, which simplifies to $a \times t$ = 48. Currently, students have multiple options available. An alternative solution to obtain a result of 48 is multiplying two numbers, such as six multiplied by 8. In this problem, the encoding stage involves constructing a right triangular upright prism with specific numerical values. For instance, we are attempting to determine the height of the prism (*h*), which is equal to 10 cm, and the area of the base (*A*), which is equal to 24 square centimetres. To achieve this, we need to establish the dimensions of the base of a right triangle, where one side (*a*) measures 6 cm and the other (*t*) measures 8 cm.

Following the comprehension stage, students encounter challenges in the subsequent stage that require more specialised abilities and a deeper understanding of mathematics. Students often struggle to associate the idea of volume with the visual representation of a right-angled prism, particularly when establishing the measurements of the base (length and height of the triangle) and the height of the prism. The subsequent data represents the cumulative score of students' responses to question number 2:

Table 3 - Student answer score for question number 2

	Score	f	%
Question Number 2	5	-	-
	4	-	-
	3	-	-
	2	22	88
	1	1	4
	0	2	8

According to the students' responses to question number 2, 8% did not take any measures to resolve the situation. Meanwhile, 88% of pupils attempted but only scored 2. Students frequently encounter challenges when confronted with mathematical problems despite studying the relevant courses. Proficiency in mathematical concepts facilitates the application of necessary formulas for problem-solving.

Moreover, the capacity to amalgamate information to construct a prism of the appropriate dimensions demonstrates students' proficiency in applying mathematical principles across many scenarios. Acquiring expertise in mathematics entails more than mere rote memorisation of formulas; it necessitates comprehending the underlying principles and effectively applying them across diverse situations. According to a study conducted by Reichenbach et al. (2014), students often have challenges converting various mathematical representations. These difficulties primarily arise from conceptual misunderstandings and issues with translation.

3.1.3. Question Number 3

This question is designed to measure HOTS, focusing on analysis and evaluation activities. In question number 3, students must understand the concept of the surface area of a rectangular pyramid. The following is question number 3, which is used to analyse student difficulties:

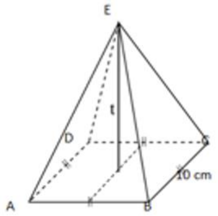
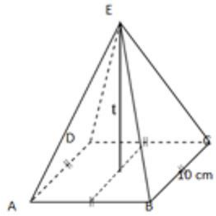
Type A	**Type B**
Pay attention to the following rectangular pyramid!  Looking at the picture above, a component is not entirely known, namely height. Can you measure the shape's height if its surface area is 360 square centimetres?	Pay attention to the following rectangular pyramid!  Looking at the picture above, a component is not entirely known, namely height. Can you measure the shape's height if its surface area is 1440 square centimetres?

Figure 5 Question number 3 to analyse student difficulties

For question number 3, students need to grasp the notion of surface area for a rectangular pyramid, which is calculated as the sum of the base area and four times the triangle area. The base area equals the square of the side length (s^2). In addition, students must comprehend the constituent elements of the triangle that constitute the pyramid's sides. Subsequently, pupils are required to assess the actions they have executed and validate them in order to ascertain their precision. Here is a response provided by a student:

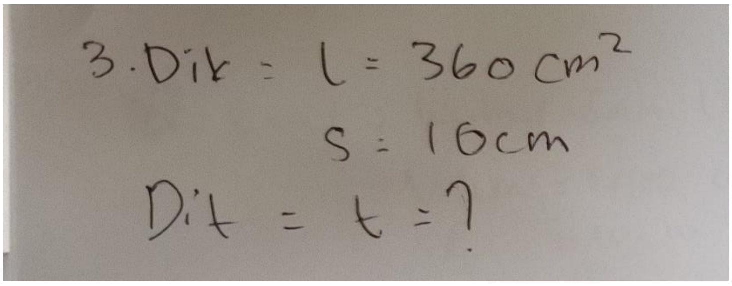


Figure 6 Student Answer Sheet for Question Number 3

Like the last topic, students encounter challenges in addressing this question with precision and accuracy. Students do not encounter challenges in reading and comprehending mathematical concepts. This demonstrates that pupils possess fundamental solid skills and can accurately comprehend the instructions derived from the supplied concepts. However, during the transformation stage, there is a suspicion that students struggle to connect the notion of surface area and determine the height of a pyramid. In this case, the area of the base is given by s^2, while the surface area of the vertical side is given by $s^2 + 4 \times \left(\frac{1}{2} \times s \times t_s\right)$. For instance, in the given situation involving variable A, the equation can be expressed as $360 = s^2 + 2s \times t_s$.

As an illustration, let us use a rectangular base with a side length of 10 cm. Using the equation $10^2 + 2 \times 10 \times t_s$, we can simplify it to $360 = 100 + 0 \times t_s$. Solving for t_s, we find that. $t_s = \frac{260}{20} = 30$. Once you have determined the height of the right-angled triangle (t_s), you can use the Pythagorean theorem to calculate the perpendicular height from the base to the top of the pyramid. The formula is $t_s^2 = \left(\frac{s}{2}\right)^2 + h^2$. As an illustration, when we substitute the values $13^2 \left(\frac{10}{2}\right)^2 + h^2$ Into the equation, we obtain $169 = 25 + h^2$. Solving for h, we find that h equals $\sqrt{122}$Cm.

According to the instructions for solving the issue, pupils can write *h* = 24 cm at the encoding stage. The subsequent score represents the students' collective performance in question number 3.

Table 4 - Student answer score for question number 3

	Score	f	%
Question Number 3	5	-	-
	4	-	-
	3	-	-
	2	15	60
	1	4	16
	0	6	24

The students' difficulty in answering question number 3 indicates that 24% of the students did not exert any effort in attempting to solve the problem. Meanwhile, 16% and 60% have tried to attain scores 1 and 2, respectively. Nevertheless, no individual has exceeded this accomplishment. An element that could exacerbate students' challenges in resolving issue number 3 is the tendency to draw erroneous conclusions.

It is crucial to discover and resolve the underlying factors that may impede the proficiency of the 24% of students who cannot answer any questions about the subject matter. This issue can impede the capacity to conduct assessments and draw conclusions. According to Lindberg and Brown (2018), this can impede comprehension of the text and hamper the capacity to make conclusions or mathematical inferences.

3.1.4. Question Number 4

This question assesses higher-order thinking skills (HOTS) by emphasising the analysis, assessment, and application of mathematical principles in creating basic architectural plans. This question requires students to comprehend the notion of volume about a cube and a rectangular pyramid. The subsequent enquiries are employed to scrutinise challenges encountered by students:

Type A	Type B
An architect is drawing a house with a cube and a rectangular pyramid, each with congruent base shapes. He wants to draw a house with a volume of 1.400 cubic centimetres and a house width of 10 cm. If you were the architect, what would the house look like?	An architect is drawing a house with a cube and a rectangular pyramid, each with congruent base shapes. He wants to draw a house with a volume of 2.112 cubic centimetres and a house width of 10 cm. If you were the architect, what would the house look like?

Figure 7 Question number 4 to analyze student difficulties

In this problem, students must understand the concept of the volume of a cube and a rectangular pyramid, namely Vcube= cubic centimetres, where s is the length of the side of the cube and Vpyramid= $\frac{1}{3}\times$ base area x height of the pyramid. Students are guided to create a tailored design to ensure it meets the specifications. The following is one student's answer:

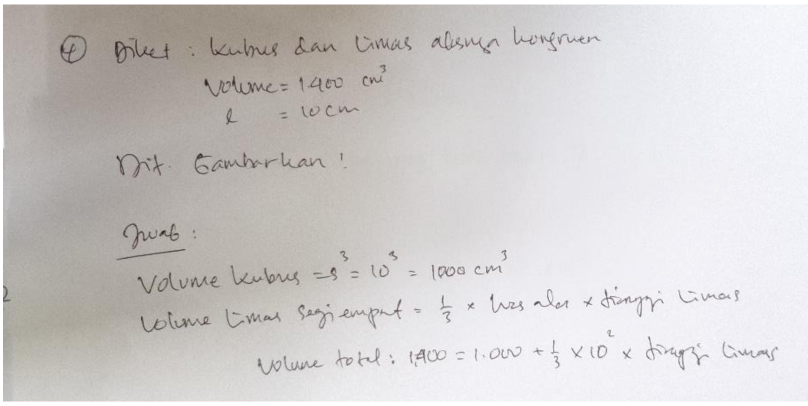


Figure 8 Student Answer Sheet for Question Number 4

Many pupils have reached the transformation stage in this question. This suggests that pupils have completed the reading and comprehension phases. During the reading stage, students can discern significant details in the issue, such as the overall volume of the home, the breadth of the building, and the different parts of the house (specifically, a cube and a pyramid) where the base of the pyramid is identical to the cube. During the understanding stage, pupils realise that they must create a house using a cube and a rectangular pyramid. The structure must have a specific total volume and the same preset base width.

The students have exhibited a commendable comprehension of fundamental mathematical principles in order to answer this problem. Consequently, during the transformation phase, the students successfully converted the problem's information into pertinent mathematical equations, specifically Total volume = Cube Volume + Pyramid Volume. Students have also stated that the volume of the cube is equal to the side length cubed, thus we may calculate that 103 is 1000 cubic centimetres. Nevertheless, children cannot get to the stage of process skills, which entails accurately doing math to determine the volume of the pyramid. While students may recognise pertinent equations, they lack a complete comprehension of effectively utilising these equations within the problem's context. Students may struggle with algebraic manipulations or forget the equation for the volume of a pyramid, which hinders their ability to proceed to the encoding stage. This stage involves drawing the requested geometric shape with particular dimensions. The subsequent score represents the collective student response for question number 4.

Table 5 - Student answer score for question number 4

	Score	***f***	**%**
Question Number 4	5	-	-
	4	-	-
	3	11	44
	2	7	28
	1	6	24
	0	1	4

The data collected from students' responses to question number 4 revealed that 44% achieved a score of 3, 28% achieved a score of 2, 24% achieved a score of 1, and 4% did not submit a response. According to this data, numerous students have attempted to resolve this issue, but have been unsuccessful. Students struggle with the task of creating suitable architectural structures. This is due to the impact of selecting the appropriate technique in resolving it. According to Ling and Mahmud (2023), the planning stage is inherently challenging as students may encounter difficulties in selecting an appropriate solution for the given problem. Moreover, according to Amin et al. (2022), students have challenges when it comes to solving mathematical issues. These challenges encompass comprehending the problem, devising a solution strategy, executing the plan, and verifying the answer.

3.1.5. Question Number 5

This task assesses higher-order thinking skills (HOTS) by quantifying the difference in volume between two blocks. In order to do precise calculations, students must be able to distinguish between known and unknown variables. Question number 5 is utilised to assess student challenges.

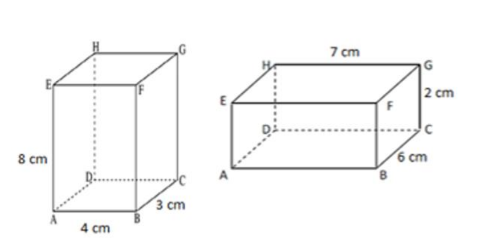
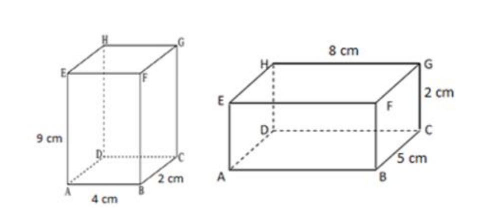
Tipe A	**Tipe B**
 Figure 1 Figure 2 Based on the picture above, which one has the larger volume?	 Figure 1 Figure 2 Based on the picture above, which one has the larger volume?

Figure 9 Question number 5 to analyze student difficulties

This task assesses HOTS by quantifying the difference in volume between two blocks. Initially, pupils must grasp the fundamental notion of block volume. Students analyse the block designs to ascertain the necessary measurements (length, breadth, height) to calculate the volume. Subsequently, students analyse the given data to compare the volume between the two blocks. According to the calculation findings, students should be able to assess the results and make inferences regarding the volume comparison between the two blocks. Here is a response provided by a student:

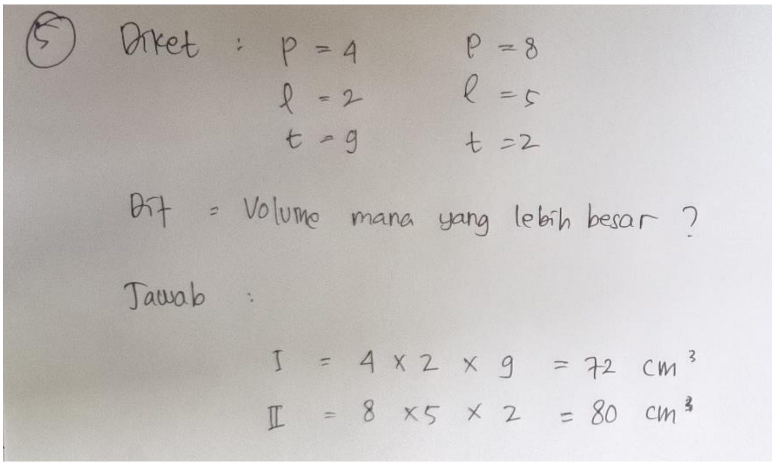


Figure 10 Student Answer Sheet for Question Number 5

This query deviates slightly from the other enquiries. Where pupils have advanced to the process skill stage without going through the transformation step, students record their existing knowledge (reading) and comprehend the given instructions (comprehension). Nevertheless, the students failed to write the appropriate formula for the transformation accurately, yet they could appropriately respond to the question by using their processing skills. However, the pupils failed to record the desired outcome, which was to compare the volumes of the shapes (encoding) and determine which was greater. The subsequent score represents the students' collective performance in question number 5.

Table 6 - Student answer score for question number 5

	Score	*f*	%
Question Number 4	5	-	-
	4	1	4
	3	-	-
	2	1	4
	1	7	28
	0	16	64

According to the students' responses, 4% of them provided nearly flawless answers, namely 4 students. One student came close to providing the correct answer to this question. Nevertheless, most (64%) of students refrained from taking any measures to address the issue. According to Nathan et al. (1992), students frequently struggle to derive crucial inferences from their reading in order to comprehend problem situations fully. This leads to substantial inaccuracies in their responses. Support for this claim is found in Voyer (2011) assertion that the nature of the information presented in a challenge and an individual's mathematical skills play a role in their ability to successfully solve difficulties.

Based on the results of analyzing student challenges with NEA, it has been observed that there are several discrepancies in students' capacity to comprehend and solve mathematical issues using flat-sided geometric objects. This research uses several metrics, including maximum value, minimum value, mean, and standard deviation, to assess the diverse levels of difficulty students encounter when attempting to accomplish an assignment. The findings from the examination of the responses provided by 25 students are as follows:

Table 7 - Description of Student Difficulty Analysis

	HOTS Dimensions/Question Number				
	(C4)/1	(C6)/2	(C5)/3	(C6)/4	(C5)/6
The number of students	25	25	25	25	25
Maximum Value	2	2	2	3	4
Minimum Value	1	0	0	0	0
Average	1.36	1.8	1.36	2.12	0.52
Standard Deviation	0.49	0.58	0.86	0.93	0.92
SMI	5	5	5	5	5

The table provided demonstrates that certain pupils face challenges in comprehending fundamental concepts, while others find it difficult to give precise yet incomplete responses. These disparities indicate that students employ diverse cognitive strategies while tackling problems. This is evident from the fluctuating range of highest and lowest ratings and the fluctuating mean values for each topic. Some students struggle to grasp the underlying ideas even when tackling more complex subjects, while others can generate nearly accurate responses. Questions 3, 4, and 5 have significant standard deviations, suggesting a considerable variation in the answers provided by pupils. Most students struggle to comprehend this subject, as evidenced by question 5, which has the lowest mean score of 0.52 and a substantial standard deviation of 0.92. Consequently, a limited number of students comprehended the questions accurately, resulting in their inability to enhance their analytical abilities to the requisite level for tackling the HOTS C5 dimension.

3.2. Discussion

The transformation step is a fundamental skill in the study of mathematical materials. Transformation is converting problems from their linguistic or contextual form into mathematical representations that may be manipulated. It is an essential step in the process of solving mathematical problems. Upon reaching this level, pupils better comprehend their challenges and identify potential solutions. During the transformation process, students clearly understand the essential elements and connections involved, which facilitates the application of mathematical concepts and activities. Nisa & Dewanti (2023) argue that a transformation is necessary to establish links between different mathematical notions and ideas, enabling the accurate application of formulas and problem-solving.

The transformation process through mathematical modelling activities entails using mathematical knowledge across different domains and the student's capacity to apply mathematical concepts and formulas in real-world situations. By employing this modelling style, students can cultivate a more profound comprehension of mathematical topics and enhance their proficiency in real-world scenarios. Chapman (1997) asserts that a crucial aspect of studying mathematics is the shift from employing less mathematical terminology to employing more advanced mathematical terminology. According to Agani (2021), this procedure entails transforming the represented visuals into mathematical and verbal symbols. Converting verbal information into mathematical models is essential for resolving challenges that arise in the real world. Hassan (2023)stated that transformation allows students to enhance their critical thinking and problem-solving capacity.

Regrettably, students frequently encounter challenges in accurately recognising and executing different mathematical manipulations (AL-Rababaha et al., 2020). Students frequently struggle to accurately identify and execute certain mathematical transformations (Mpuangnan & Ntombela, 2024). High school pupils often have challenges while manipulating algebraic expressions (Angraini et al., 2023; Ferretti & Karbstein, 2019; Palwa et al., 2024). Moreover, youngsters may encounter difficulties comprehending that transformations symbolise abstract mathematical ideas, leading to obstacles in transferring information from physical objects to written answers (Uttal et al., 2013). Foundational abilities in numeracy, including counting, number recognition, and amount manipulation, significantly impact mathematics ability (Raghubar et al., 2009).

Challenges in this mathematical conversion might impede pupils' problem-solving skills and overall mathematical achievement. Hia's (2023) research indicates that students frequently encounter difficulties comprehending mathematical concepts, impeding their ability to apply mathematical formulas accurately. Such issues can develop when pupils lack comprehension of the subject matter or exhibit a general disinterest in mathematics. Students may encounter challenges in problem-solving if they struggle with the process of transforming word problems into mathematical equations and determining the most suitable mathematical operations to use (Kania & Juandi, 2023; Klymchuk, 2015). This may be a contributing aspect that impedes their capacity to resolve challenges.

To support children in acquiring strong mathematical problem-solving skills, it is crucial to address these issues by providing tailored instruction and interventions focusing on increasing transformation skills and comprehension of mathematical ideas. Educators are responsible for supporting students to help them overcome the difficulties they encounter while working with numbers and equations. This is important because it can significantly affect their comprehension of mathematical concepts. This can be accomplished by offering students many opportunities to engage in practice while also providing them with constructive input and ideas. Teachers can enhance students' mathematical proficiency and problem-solving acumen by offering systematic practice, constructive comments, and assistance.

Both Huan et al. (2022) and Seman et al. (2018) discovered that employing manipulatives and following a sequence of schemes to abstracts were two successful approaches in aiding students' comprehension of mathematical ideas and, as a result, their accurate application of formulas. Umaroh (2021) argue that professors who help students develop solid conceptual understanding and establish linkages to real-world contexts can bridge the gap between theoretical mathematics and its practical application. In order to correctly solve mathematical problems using formulae, students must possess a comprehensive comprehension of the fundamental principles of mathematics.

Proficiently solving mathematical issues necessitates a comprehensive grasp of mathematical principles and the ability to engage in critical and innovative thinking. Newman proposes a framework consisting of five stages for analysing difficulty levels. In general, students tend to encounter challenges, specifically during the transition stage. Newman (1977) suggests that to enhance students' proficiency at the transformation stage, they can be instructed to convert issues into mathematical equations to enhance this skill. Engaging in exercises involving different problem kinds and transformation stages is crucial for students to develop their ability to identify the necessary patterns and techniques. Adopting a systematic method of transforming problem information into mathematical expressions is crucial for accurately addressing mathematical problems.

Student achievement at the transition stage entails pupils being more proficient in applying procedural skills, wherein they must systematically follow logical methods to solve mathematical problems. Typically, the progress of the skill stage relies heavily on the suitable transformation stage. Students must perform computations and accurately utilise the appropriate equations at this juncture. Ampur et al. (2021) contend that once pupils have attained proficiency in the transformation stage, they are prone to committing fewer errors in the completion stage. This is because they possess a well-defined understanding of utilising the information they have acquired. In order to enhance students' proficiency in utilising formulas and effectively solving mathematical problems, it is imperative to address the difficulties they encounter in comprehending mathematical concepts. This can be achieved by employing suitable modelling techniques and relevant instructional strategies.

4. Conclusions

After reviewing the provided material, Newman discovered that most eighth-grade students encountered difficulties with transformation-based geometry assignments. We converted spoken challenges into more practicable mathematical formulas during this transition phase. The underlying causes of these issues are a lack of conceptual comprehension and the inability to visualise the data in relation to the relevant geometric concepts. Most students find it difficult to transform verbal descriptions of problems into mathematically solid, concrete models. This is especially true in mathematics programs that emphasise critical thinking, evaluation, and innovative concepts. These findings underscore the pressing necessity for students to enhance their comprehension of geometric visualisation principles.

This study recommends that teachers integrate more interactive and visually appealing activities into their lessons to ensure that students flourish during this period of transition.

Educators may implement learning strategies, including problem-based learning, visualisation technology, and security measures, to assist students in more effectively converting issues into mathematical forms. This will be accomplished through the development and implementation of such methodologies. Educators can assist students in preparing for problems that necessitate higher-level thinking by offering supplementary lessons that emphasise developing HOTS skills. Consequently, it is feasible to elevate the standard of geometry education, which may ultimately assist students in developing their problem-solving abilities.

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Conflict of Interest
The authors declare no conflicts of interest.

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