AN ANALYSIS OF STUDENT ERRORS IN SOLVING HIGHER ORDER THINKING SKILLS PROBLEMS ON NUMBER PATTERNS USING NEWMAN'S THEORY

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ABSTRACT In an era where Artificial Intelligence is reshaping various sectors, education must evolve to equip students with the skills required to tackle complex future challenges. Mathematics, as a fundamental subject, plays a crucial role in fostering Higher Order Thinking Skills (HOTS), which are essential for problem-solving in diverse real-world contexts. This study investigates student errors in solving HOTS problems on number patterns at SMPN 23 Pekanbaru, utilizing Newman's Error Analysis framework. A qualitative descriptive approach was employed, with data collected through written tests and interviews. The study involved 26 students from class VIII D during the second semester of the 2023/2024 academic year. Data analysis was conducted inductively, classifying errors according to Newman's stages. The findings revealed that the most frequent errors occurred during the comprehension stage (69%) and encoding stage (54%), largely due to students' inadequate understanding of number pattern concepts and limited exposure to varied HOTS problems in the classroom. These results highlight the need for a broader range of HOTS problems in mathematics education to better develop students' higher-order thinking abilities. The study recommends that educators diversify problem types, offer guided problem-solving activities, and engage in action research to refine teaching methods and enhance student outcomes.

Keywords: higher order thinking skills (HOTS), newman's theory, error analysis, number patterns, mathematics.

ABSTRAK Di era di mana Kecerdasan Buatan (AI) semakin mempengaruhi berbagai sektor, pendidikan harus berkembang untuk membekali siswa dengan keterampilan yang dibutuhkan untuk menghadapi tantangan masa depan yang kompleks. Matematika, sebagai mata pelajaran dasar, memainkan peran penting dalam mengembangkan Keterampilan Berpikir Tingkat Tinggi (HOTS) yang esensial untuk pemecahan masalah dalam berbagai konteks kehidupan nyata. Penelitian ini meneliti kesalahan siswa dalam menyelesaikan soal HOTS pada pola bilangan di SMPN 23 Pekanbaru, menggunakan kerangka Newman's Error

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Analysis. Pendekatan deskriptif kualitatif digunakan, dengan data dikumpulkan melalui tes tertulis dan wawancara. Studi ini melibatkan 26 siswa kelas VIII D selama semester dua tahun ajaran 2023/2024. Analisis data dilakukan secara induktif, mengklasifikasikan kesalahan sesuai dengan tahap-tahap Newman. Hasil penelitian menunjukkan bahwa kesalahan paling banyak terjadi pada tahap pemahaman (69%) dan tahap pengkodean (54%), yang disebabkan oleh pemahaman konsep pola bilangan yang kurang dan kurangnya variasi soal HOTS di lingkungan sekolah. Temuan ini menyoroti perlunya variasi soal HOTS yang lebih luas dalam pendidikan matematika untuk meningkatkan keterampilan berpikir tingkat tinggi siswa. Penelitian ini merekomendasikan agar para pendidik memperbanyak jenis soal HOTS, menyediakan sesi pemecahan masalah dengan bimbingan, serta melaksanakan penelitian tindakan untuk menyempurnakan metode pengajaran dan meningkatkan hasil belajar siswa.

Keywords: kemampuan berpikir tingkat tinggi, analisis kesalahan, pola bilangan, teori newman.

INTRODUCTION

In the 21st century, the integration of technology into daily life has introduced both opportunities and challenges, with artificial intelligence (AI) being one of the most significant. According to Rahmawati (2022), AI holds immense potential to transform how humans live, as many tasks once performed by individuals are now handled by AI, necessitating adaptation in various aspects of life, particularly education. Education today can no longer solely focus on imparting basic knowledge or simple skills like memorization and formula application. The Ministry of Education and Culture (Kemendikbud), in its 2017 guidebook, emphasized the need to prepare students with Higher Order Thinking Skills (HOTS) to meet the demands of a rapidly evolving world (Kemendikbud, 2017).

The importance of HOTS in education is further supported by Ratri & Azhar (2022), who argue that teaching focused on fostering HOTS has a positive impact on students' cognitive development. In this regard, mathematics plays a crucial role in developing these skills. Ratnasari, Dwi Rosita, & Amami Pramuditya (2017) suggest that mathematics helps shape children's thinking patterns. This aligns with Yuwono, Supanggih, & Ferdiani's (2018) view that through mathematics, students can learn to approach problems with logical and systematic reasoning. Consequently, mathematics instruction in schools focuses on cultivating students' ability to think critically, systematically, and solve problems—key elements of HOTS.

One effective method of enhancing HOTS in mathematics is through the use of HOTS questions. Rochman & Hartoyo (2018), based on the revised Bloom's Taxonomy by Krathwohl & Anderson, explain that HOTS questions in the cognitive domain require students to analyze (C4), evaluate (C5), and create (C6). Such questions not only assess students' skills but also encourage them to engage in more complex thinking processes. Conklin (cited in Siregar & Nasution, 2019) even states that HOTS is a key indicator of success in developing human resources through education.

Despite the recognized importance of HOTS, Indonesian students still demonstrate relatively low levels of higher-order thinking skills. This is evident in the results of the Program for International Student Assessment (PISA), where Indonesia continues to rank poorly compared to other countries, with declining scores since 2015 (PISA 2022 Results (Volume I), 2023; PISA 2022 Results (Volume II), 2023). Indonesian students rarely achieve the highest levels of mathematical proficiency in PISA, indicating an urgent need to enhance HOTS development efforts in the country. A detailed analysis of the errors students make when solving HOTS-related problems is therefore critical to address this issue.

Newman's theory offers a valuable framework for analyzing the types of errors students make when solving mathematical problems. Lusbiantoro (in Amini & Yunianta, 2018) outlines five types of errors in Newman's theory: (1) Reading errors occur when students misinterpret the problem text, often due to inattention or language comprehension issues. (2) Comprehension errors arise when students struggle to understand the meaning of the question, preventing them from identifying the correct solution. (3) Transformation errors occur when students understand the problem but fail to determine the correct mathematical procedures to solve it. (4) Processing skill errors happen when students know the correct procedure but make mistakes in calculations. (5) Encoding errors occur when students incorrectly link their answer to the problem, thus altering its meaning.

By applying Newman's theory, educators can identify the types of errors students make and take targeted corrective actions. Prior research has shown that the dominant error types vary across different schools. For example, a study by Mahmudah (2018) at SMP Negeri 1 Gresik found that comprehension errors were the most prevalent (69%), while research at SMPN 1 Mataram by Sejati, Baidowi, Salsabila, & Turmuzi (2023) indicated that the most common errors were in processing skills (72%). At MTs YMI Wonopringgo, Maulida et al. (2022) found that encoding errors were the most frequent (53%). These findings suggest the need for further research in various regions to better understand specific student errors and develop strategies to improve HOTS.

An interview conducted at SMPN 23 Pekanbaru, revealed that previous summative test results indicated that students had not yet achieved the expected level of HOTS, with an average student score of 60. Among the topics covered, number patterns had the most below-average scores. The teacher also admitted that no error analysis had been conducted for Class VIII D at SMPN 23 Pekanbaru. Thus, this study aims to analyze student errors in solving HOTS questions on number patterns using Newman's theory. By identifying student errors, this analysis is expected to assist educators and educational institutions in evaluating and improving learning methods to enhance students' higher-order thinking skills.

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METHODS

This study uses a qualitative descriptive approach to identify students' errors in solving Higher Order Thinking Skills (HOTS) questions related to number patterns. As described by Zellatifanny and Mudjiyanto (2018), descriptive research aims to gather factual data about the state or situation of a phenomenon that emerges during the study. It is essential for illustrating an ongoing situation in detail while addressing issues that arise throughout the research. The study population includes all 26 students in Class VIII D at SMPN 23 Pekanbaru, and the research was conducted in the second semester of the 2023/2024 academic year.

The data collection methods consist of written tests containing HOTS questions administered to all students, as well as interviews conducted with a selected subset of students using purposive sampling. The students will be assigned codes (e.g., S1, S2, S3, etc.) to facilitate analysis, with the selection of interview participants based on students who made the most frequent errors for each question indicator.

The written tests aim to observe patterns in students' errors, while the interviews serve to validate these errors by examining the students' understanding of the material and their thought processes when answering the questions. The researcher will act as a complete observer to minimize any interactional bias during the study.

Following the test results, the errors will be analyzed using Newman's theory. Error indicators will be reviewed and adapted from various previous studies, such as those by Rohmah, Widadah, and Agustina (2021), Lusbiantoro (in Amini & Yunianta, 2018), and Clement (in Mahmudah, 2018). These indicators will be organized and presented in Table 1.

Table 1. Indicators of Errors Based on Newman's Theory

No	Types of Errors	Indicators
1	Reading Error	1. Misreading letters, words, or phrases. 2. Incorrectly identifying information. 3. Not utilizing information to solve problems or failing to provide an answer.
2	Comprehension Error	1. Omitting information or key terms from the question. Failing to write down and/or explain the information known from the question. 2. Not writing down or being unable to explain what the question is asking. 3. Omitting information or key terms from the question. 4. Students have difficulty grasping the overall meaning even though they are able to read all

No	Types of Errors	Indicators
		the words, which hinders their ability to proceed with solving the problem.
3	Transformation Error	1. Unable to create a mathematical model from the given problem, even though understanding the intent of the question. 2. Not writing down the formula/method used and being unable to explain the process. 3. Incorrect use of formulas/methods. 4. Omitting or inaccurately applying the sequence of formulas/methods to solve the problem.
4	Process Skill Error	1. Not continuing with the procedure. 2. Unable to execute the procedure or steps accurately. 3. Error in performing calculations. 4. Not writing down the calculation steps and being unable to explain the process.
5	Endcoding Error	1. Not providing the final answer. 2. Incorrect use of notation/units. 3. Providing an incorrect conclusion. 4. Unable to explain the result.

The research instruments consist of a HOTS test developed by Putri (2022), with questions selected based on internal validation scores, difficulty levels, discriminatory power, curriculum relevance, and informed by preliminary test results from December 16, 2023, which involved nine students from Class VIII H. The HOTS questions were completed individually by the students participating in this study. Additionally, a semi-structured interview guide was created, aligned with the error indicators identified through Newman's theory, to explore the specific types of errors made by the students.

The data analysis is conducted inductively, starting with data reduction. The collected data is examined by identifying and classifying student errors according to Newman's theory. The results are then presented as percentages for each type of error, accompanied by detailed explanations of the factors contributing to these errors.

To ensure the validity of the data, source triangulation techniques are employed. This involves cross-referencing the test results and interviews from each student to serve as comparative material for evaluating the accuracy of the information. Abdussamad & Sik (2021) emphasize that qualitative research requires a structured process to evaluate how applicable or relevant the findings are in different contexts.

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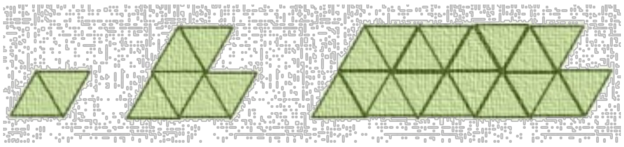
This is done to guarantee that the conclusions drawn are both accurate and valid, adhering to the principles of qualitative research.

FINDING AND DISCUSSION

This study began with administering a written test consisting of HOTS-type mathematics questions on number patterns. The test was conducted on April 26, 2024, with students being given 6 questions to answer. The assessment was carried out factually according to the established parameters. The questions administered are presented in Table 2.

Table 2. Questions administered

No	Question
1	The following sequence of numbers is formed from positive integers, which are a combination of multiples of 2 and multiples of 3: 2, 3, 4, 6, 8, 9, 10, 12, … Is it true that 3,032 is the 2,000th term or the 2,021st term?
2	The sum of 2,023 consecutive integers equals 6,069. Prove that 2,022 is the difference between the largest and smallest numbers in the sequence!
3	The sum of 996 terms of an arithmetic sequence is 3,984. Construct the arithmetic sequence if the difference between terms is 4.
4	Observe the pattern below:  Fatma is arranging shrimp-filled risoles in a triangular shape into several containers as shown in the image, forming a number pattern. Based on the pattern above, is this sequence an arithmetic or geometric sequence?
5	A geometric sequence has its first term as an even number within a certain range and has a ratio consisting of odd numbers within a range. Create the configuration of objects for the 2nd term of the sequence formed!

Interviews were conducted with students who exhibited significant increases in specific errors to gain a deeper understanding of the causes of these errors. Below is a summary of the errors made by students in solving HOTS questions in Class VIII D at SMPN 23 Pekanbaru.

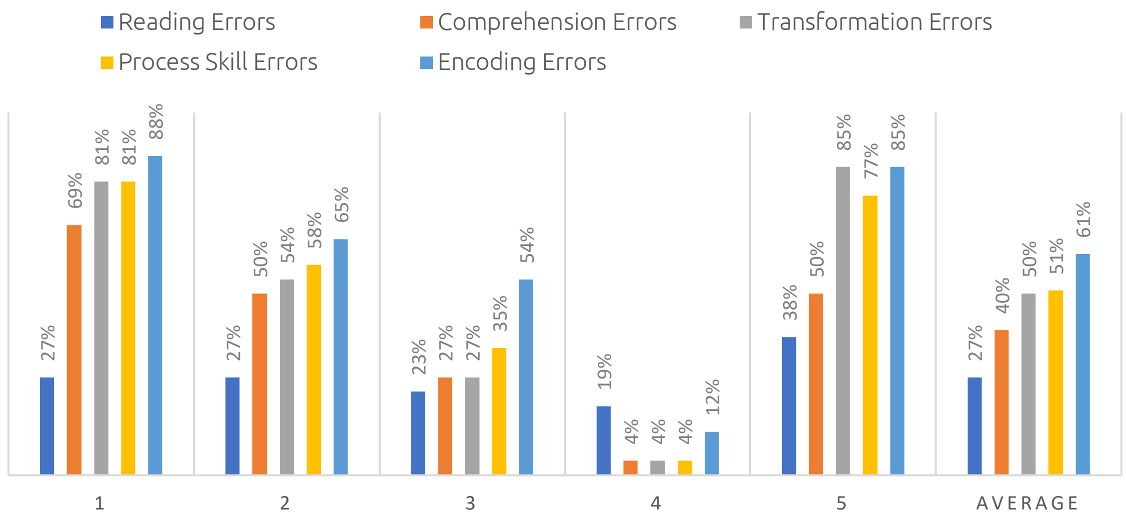


Figure 1. Percentage of Student Errors for Each Question

Question Number 1 shows that students made errors in the reading stage at a rate of 27%, and in the comprehension stage at a rate of 69%. This indicates a significant increase, approximately 2.5 times the errors in the reading stage.

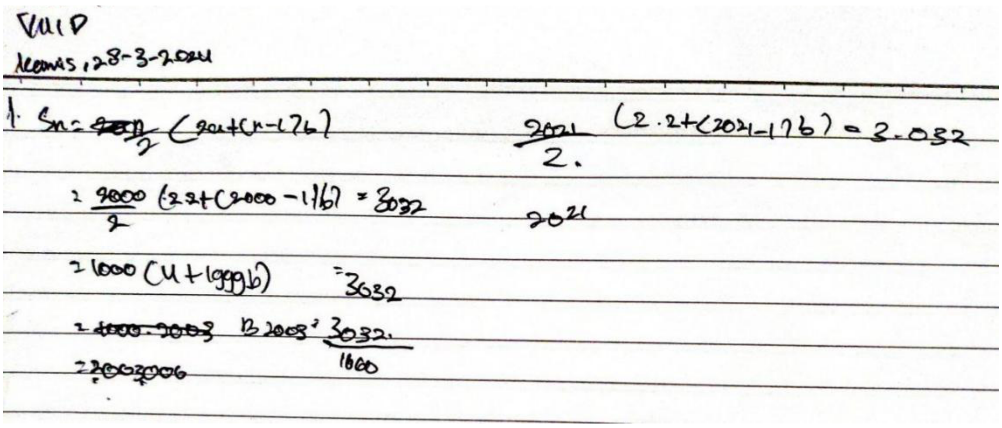


Figure 2. Test Results for S10 Question Number 1

The researcher interviewed three students. One of them S10, experienced difficulty in understanding the question. The subject was confused about the difference between sequences and arithmetic series, leading to incorrect application of calculations. S10 incorrectly applied the method for arithmetic series, which was the wrong approach. The interview revealed that although S10 could read the key information, he did not grasp the overall meaning of the question, which led to errors in subsequent stages.

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The largest increase in Question Number 2 is seen at the comprehension stage, with errors rising to 50% compared to 27% in the reading stage. This indicates that half of the students failed to answer the question correctly at the comprehension stage.

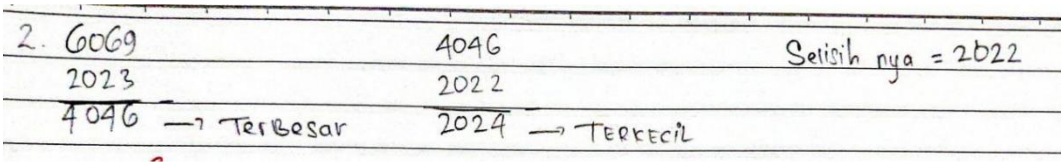

Figure 3. Test Results for S13, Question Number 2

The researcher interviewed three students. One of the students, S13, experienced difficulty understanding the question about the largest and smallest differences between numbers. This error indicates that the student was unfamiliar with the concept of difference in the context of number patterns. The problem should have been solved by determining the sequence of numbers indicated by the "jumlah(sum)" information in the question. Although S13 was able to read the question correctly, a lack of understanding led to errors in the transformation and process skills stages.

Question Number 3 shows the largest error rate at the endcoding error stage, with a percentage of 54%. The researcher interviewed two students.

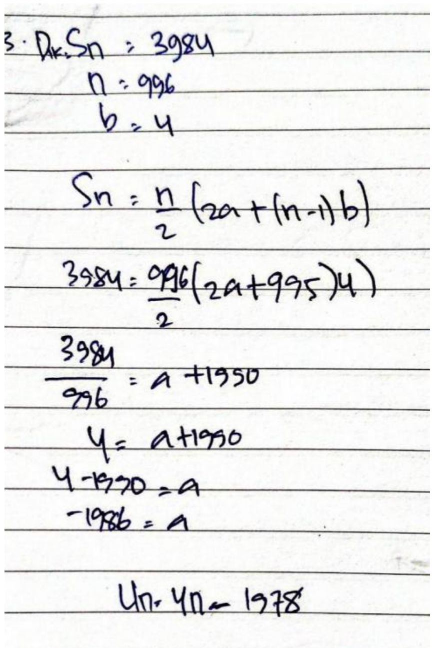

Figure 4. Test Results for S4, Question Number 3

One of them, S4, was able to complete the mathematical calculations correctly but forgot to write down the final result required by the question. This error was caused by a lack of attention and hurrying to finish the question. Despite understanding the material and performing the calculations correctly, the error in recording the final answer altered the intended meaning of the response.

Question Number 4 shows no increase in errors; instead, the opposite occurred. Initially, 19% of students made mistakes at the reading stage, but after retesting, they were able to complete the question correctly, reducing the comprehension errors to only 4%. The researcher interviewed three students. S3, one of the students, made reading errors due to overlooking important information in the question.

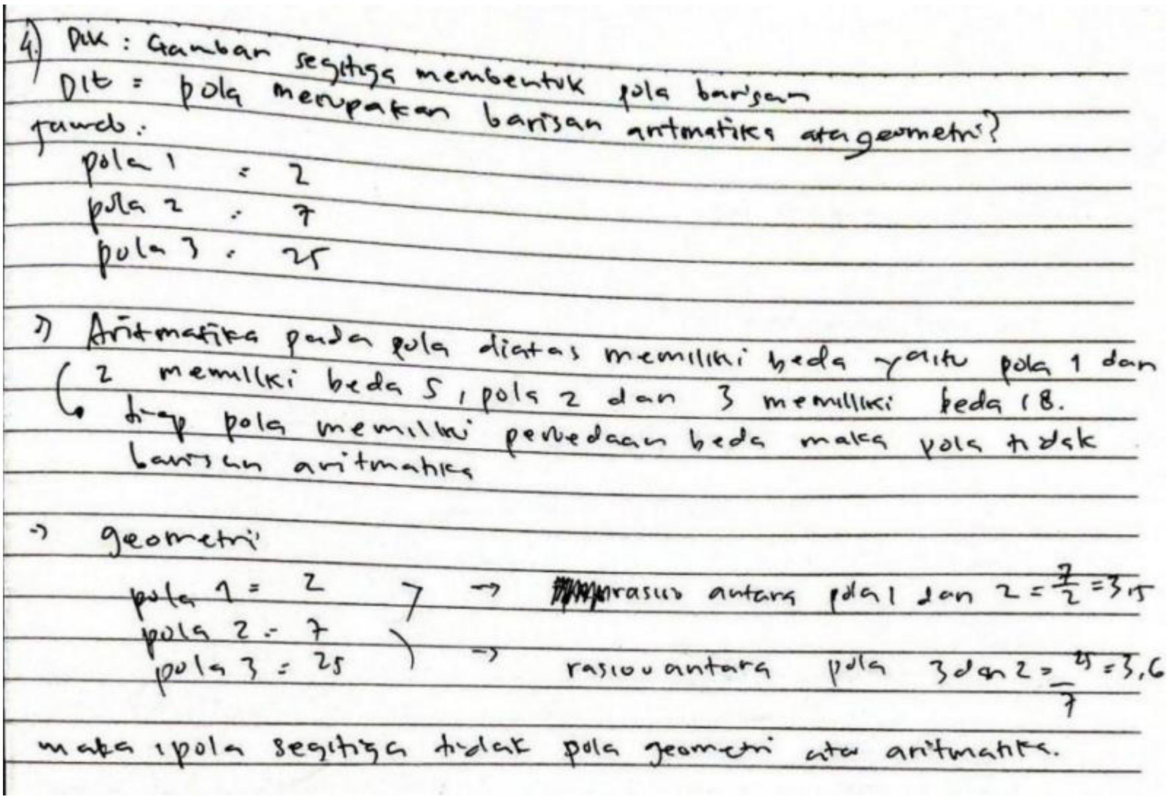
4) Dik : Gambar segitiga membentuk pola barisan
Dit : pola merupakan barisan aritmatika atau geometri?
Jawab :
pola 1 : 2
pola 2 : 7
pola 3 : 25
-> Aritmatika pada pola diatas memiliki beda yaitu pola 1 dan 2 memilliki beda 5, pola 2 dan 3 memilliki beda 18. tiap pola memiliki perbedaan beda maka pola tidak barisan aritmatika
-> geometri
pola 1 = 2 -> rasio antara pola 1 dan 2 = 7/2 = 3,5
pola 2 = 7
pola 3 = 25 -> rasio antara pola 3 dan 2 = 25/7 = 3,6
maka pola segitiga tidak pola geometri atau aritmatika.

Figure 5. Test Results for S3 Question Number 4

Shown in Figure 5, S3 understood the material well, but errors in reading important information led to mistakes in the provided answers. The retest demonstrated that S3 was actually able to solve the problem correctly after accurately understanding the context of the question.

In Question Number 5, the largest error occurred at the transformation stage, with a percentage of 85%. The researcher interviewed two students. S1, one of the students, experienced difficulty recalling the formula for geometric sequences due to infrequent exposure to such questions.

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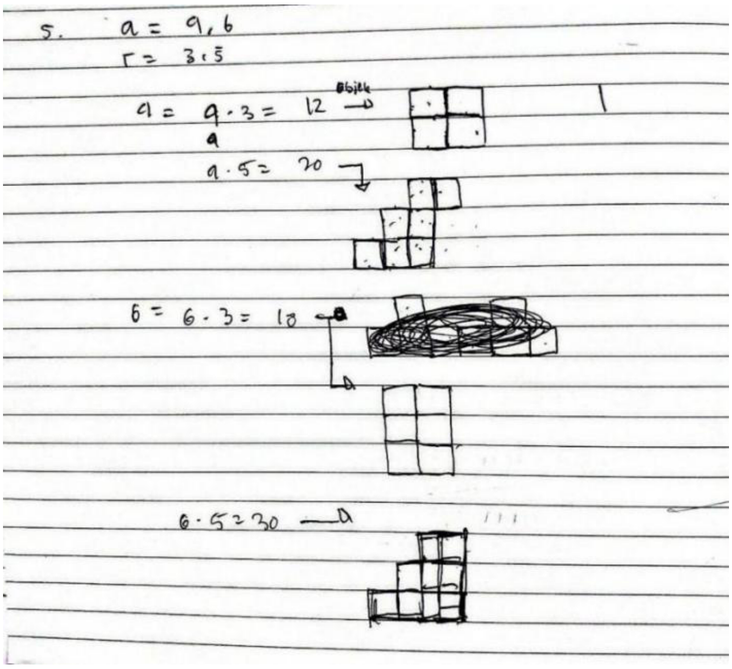

Figure 6. Test Results for S1 Question Number 5

S1's answers indicate that the student is not familiar with the variations of HOTS questions involving geometric concepts. Although able to read the key information, errors in transformation and concept understanding led to mistakes in the process skills stage and the endcoding stage.

Based on the results of the HOTS questions and interviews, students made various types of errors while solving mathematics problems on number patterns. The highest error rate was at the endcoding stage (61%), while the lowest was at the reading stage (27%). Reading errors are typically caused by a lack of focus and haste, while understanding errors often occur because students are not accustomed to answering questions systematically.

Transformation errors occurred when students failed to choose the correct mathematical operation, with an error rate of 50%. This is usually due to a lack of understanding of the steps or formulas that should be used. Calculation process skill errors (51%) were caused by a lack of precision and mastery of arithmetic operations. Errors at the endcoding stage were often due to carelessness, haste, and a lack of habit in drawing conclusions.

CONCLUSIONS AND RECOMMENDATIONS

The error analysis based on Newman's procedure reveals that students primarily struggled with comprehension and encoding stages. These errors were largely attributed to limited exposure to diverse HOTS (Higher Order Thinking Skills) questions in school, which left students unaccustomed to questions requiring deep understanding and critical thinking. Interview results indicated that students who could fully grasp the context of a problem were more likely to solve it correctly, while comprehension errors often triggered a cascade of mistakes in subsequent steps.

The findings highlight the need to improve students' conceptual understanding and to incorporate a greater variety of HOTS questions in classroom instruction. Teachers should present more challenging problems that encourage deeper understanding and higher-order thinking to help students adapt to complex tasks. By addressing these areas, students are expected to reduce comprehension errors and improve their ability to solve HOTS questions effectively.

Recommendations for educators include increasing the use of HOTS questions, offering targeted problem-solving guidance, and conducting classroom action research (CAR) to enhance teaching strategies. Future researchers are encouraged to further analyze student errors using Newman's procedure across different mathematical topics.

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