Research Article

Adji Winarko[1]*, Rahyu Setyani[2], Hikmah Eva Trisnantari[3]

Analysis of Students' Thinking Errors in Solving HOTS-Based Mathematics Problems at SMP Negeri 1 Kedungwaru Tulungagung

*Corresponding Author: **Adji Winarko**: Universitas Bhinneka PGRI, Indonesia; adji.kaspersky18@gmail.com
Rahyu Setyani: Universitas Bhinneka PGRI, Indonesia; rahyusetiani@gmail.com
Hikmah Eva Trisnantari: Universitas Bhinneka PGRI, Indonesia; Hikmaheva@gmail.com

DOI: https://doi.org/10.47353/ijedl.v3i5.322 | **received** June 17, 2025; **accepted** June 24, 2025; **online** June 30, 2025

Abstract: Higher Order Thinking Skills (HOTS) are essential competencies in mathematics learning to face the challenges of the 21st century. However, junior high school students often experience difficulties in solving HOTS problems, indicating the presence of systematic thinking errors. These errors, if not explained in depth, can hinder students' cognitive development and problem-solving abilities. This study aims to analyze the types of thinking errors made by students in solving HOTS-based mathematics problems using the Newman Error Analysis approach. This study uses a qualitative descriptive approach. The subjects consisted of 10 seventh-grade students of SMP Negeri 1 Kedungwaru, classified based on their ability levels (high, medium, and low). Data collection techniques included administering HOTS questions, think-alouds, and semi-structured interviews. Data were analyzed based on Newman's five error categories: reading, understanding, transformation, process skills, and answer writing. The results showed that students' thinking errors in solving HOTS math problems were caused by various factors. Reading errors arose from unfamiliarity with mathematical terms, misunderstanding of problem sentences, confusing question length, and low analytical skills. Comprehension errors were caused by the inability to identify information and difficulty formulating data into mathematical sentences. Transformation errors occurred due to the inability to translate information into mathematical form and a lack of experience working on contextual problems. Process skill errors were influenced by weak arithmetic skills and unfamiliarity with following procedures for solving story problems. Meanwhile, answer writing errors were caused by inaccuracy, weak arithmetic skills, and unfamiliarity with writing final conclusions.

Keywords: Newman Analysis, HOTS, Thinking Errors, Mathematical Problems.

Introduction

Education plays a crucial role in shaping a generation that is adaptive, innovative, and competent in facing the global challenges of the 21st century. Mathematics is a strategic discipline in preparing students for this era, as it not only teaches numerical skills but also fosters critical, logical, systematic, and creative thinking (Kilpatrick, Swafford, & Findell, 2001). The National Council of Teachers of Mathematics (2000) emphasized that meaningful mathematics learning must foster sustainable reasoning and problem-solving skills.

The Indonesian National Curriculum has responded to this challenge by emphasizing the importance of higher-order thinking skills (HOTS), which include analysis (C4), evaluation (C5), and creation (C6) in the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001). HOTS serves as the primary framework for various forms of assessment, such as the Minimum Competency Assessment (AKM), which aims to foster reflective, in-depth, and contextual thinking (Ministry of Education and Culture, 2018). This effort is crucial in supporting students' numeracy literacy to prepare them for the complexities of the Industrial Revolution 4.0 and Society 5.0 (Trilling & Fadel, 2009).

However, the reality on the ground shows that students still experience difficulties in solving HOTS-based problems. This difficulty is not only related to poor mastery of the material but also to the emergence of systematic and repetitive thinking errors. Santos and Pinto (2021) found that students often experience logical and metacognitive barriers when solving high-level problems. Widodo and Wibowo (2020) also emphasized that these types of errors are consistent and can be traced to specific thinking patterns that have not yet developed optimally.

Previous research has identified various forms of thinking errors in solving HOTS problems, such as conceptual, procedural, and technical errors (Rahmawati, 2020; Rachmadi & Mustaji, 2019). Technical errors, such as miscalculations or misreading numbers, are often overlooked, even though they can reflect weak self-regulation and metacognitive awareness in students. In the context of scaffolding-based learning, mapping these errors is key to developing more effective and personalized learning interventions (Santrock, 2011; Vygotsky, 1978).

The urgent need to strengthen mathematical literacy is also demonstrated by the results of the 2018 PISA survey, in which only 28% of Indonesian students were able to achieve level 2 or higher on the mathematical competency scale (OECD, 2019). This fact indicates that Indonesian students' HOTS skills are still low and require special attention through adaptive learning strategies. One approach that has proven effective is Newman Error Analysis, which identifies five types of thinking errors in solving math problems: errors in reading, comprehension, transformation, process skills, and answer writing (Newman, 1983).

This approach has been widely used in research to analyze failure points in students' mathematical thinking processes (Karnasih, 2020; Kurniadi, Fauzan, & Chandra, 2018). Sa'adah et al. (2019) also revealed that students often fail to understand the meaning of problems and construct appropriate mathematical sentences, resulting in errors in the final solution. Therefore, teachers need to design learning that is not only outcome-oriented but also focuses on students' systematic and reflective thinking processes (Newell & Simon, 1972).

Based on initial observations at SMP Negeri 1 Kedungwaru, Tulungagung, it was found that students still make various forms of thinking errors when solving HOTS-based math problems, particularly in reading the problem and understanding its context. Therefore, this study was conducted to analyze in-depth the forms and causes of students' thinking errors using the Newman Error Analysis approach, thus serving as a reference for teachers in designing more targeted and meaningful learning.

Method

This study provides a detailed investigation into the types of thinking errors made by Grade VII students while solving Higher Order Thinking Skills (HOTS) mathematics problems. By using a qualitative descriptive approach, this research sheds light on students' cognitive processes and the errors they make in the problem-solving process, based on Newman's Error Analysis. The errors were categorized into five main types: reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors. These categories serve as the primary lens for understanding the challenges students face in solving complex mathematical problems.

The research was conducted at SMP Negeri 1 Kedungwaru in East Java, Indonesia, and involved ten students from Grade VII, categorized into high, medium, and low academic levels. The purposive selection of these students ensured a diverse representation of mathematical thinking abilities. The research unfolded in three stages: preparation, implementation, and conclusion, with data gathered through multiple techniques such as observations, the HOTS Mathematics Problem-Solving Test (TPMMH), think-aloud protocols, and semi-structured interviews.

The preparation stage aimed to identify the presence of thinking errors in students when solving HOTS problems. Preliminary observations highlighted the relevance of these errors in the context of the study, laying the groundwork for the investigation. In the implementation stage, students were asked to solve HOTS problems while verbalizing their thought processes through think-aloud protocols. These sessions provided valuable insights into how students approached mathematical problems and highlighted the areas where their thinking diverged from accurate solutions. The think-aloud sessions were recorded and later analyzed, adding depth to the findings. Semi-structured interviews further enriched the data by offering clarification on students' strategies and reasoning, thus improving the validity of the findings.

Data collection focused on documenting students' written work, recorded think-aloud protocols, and interview notes. This multifaceted approach ensured a comprehensive understanding of students' cognitive processes and helped triangulate the findings for greater reliability. The researcher analyzed the data by categorizing students based on their academic levels and the results of the TPMMH. Data reduction helped to simplify and organize the findings, while data presentation in narrative form provided a clearer representation of the students' thought processes and errors.

The core of the analysis focused on Newman's Error Analysis, using its five error categories to analyze the types of thinking mistakes made by the students. The results revealed a range of errors across the different academic levels, with students from different groups showing varying frequencies and types of thinking errors. These findings were cross-verified with interview data, ensuring that the identified errors were truly reflective of the students' cognitive struggles. The research findings also pointed out that while errors were prevalent across all levels, high-level students made fewer errors overall, though still struggled with comprehension and transformation errors.

The data's validity was ensured through method triangulation, wherein different data sources—such as the TPMMH, think-aloud protocols, and semi-structured interviews—were cross-examined. This helped the researcher identify consistent patterns of errors and validate the findings through repeated data collection until saturation was reached. The triangulation of methods provided robust evidence that the thinking errors identified were both relevant and significant in the context of HOTS-based mathematics education.

This study offers a valuable contribution to understanding the thinking errors students make while solving HOTS mathematics problems. It emphasizes the need for tailored instructional strategies to address these cognitive challenges and improve students' problem-solving abilities. The findings can guide educators in designing more effective teaching approaches that focus on enhancing comprehension, transformation skills, and the overall development of higher-order thinking abilities in mathematics.

Results and Discussion

This study aims to analyze students' thinking errors in solving Higher Order Thinking Skills (HOTS)-based mathematics problems at SMP Negeri 1 Kedungwaru. The analysis employs Newman's Error Analysis, which includes five types of errors: reading, comprehension, transformation, process skills, and encoding. Data were collected through the HOTS Mathematics Problem-Solving Test (TPMMH), think-aloud protocols, and semi-structured interviews with 10 students from three different ability categories.

General Overview of TPMMH Results

The results of the HOTS Mathematics Problem-Solving Test (TPMMH) indicate that all subjects—from high, medium, and low ability categories—committed one or more types of errors when solving HOTS-based mathematics problems. The following is a summary of the errors found based on Newman's Error Analysis:

Tabel 1. Recapitulation of Students' Thinking Errors Based on Newman's Analysis

Subject	Ability	Reading	Comprehension	Transformation	Process	Encoding (Answer Writing)
S1	High	×	✓	✓	✓	×
S2	High	×	×	×	✓	✓
S3	High	×	×	✓	×	×
S4	High	×	×	×	×	×
S5	Medium	✓	✓	✓	✓	✓
S6	Medium	×	✓	×	✓	×
S7	Medium	×	×	✓	×	✓
S8	Medium	×	✓	✓	✓	✓
S9	Low	✓	✓	✓	✓	✓
S10	Low	✓	✓	×	✓	×

Note: ✓ = error occurred; × = no error occurred

From the table above, it can be seen that subjects with low ability tend to make errors in almost all categories, whereas subjects with high ability make fewer errors, especially in the initial stages such as reading and comprehension.

1. Reading Errors
   Reading errors were found in three students (S5, S9, S10). These errors occurred because the students did not understand the mathematical terms used in the problem. For instance, Subject S9 did not fully grasp the meaning of the term *"decimal"*, which led to failure in ordering numbers as instructed. This finding is consistent with Kurniadi et al. (2018), who state that reading errors are the initial barrier in solving mathematical problems.
2. Comprehension Errors
   Six subjects experienced errors at the comprehension stage (S1, S5, S6, S8, S9, S10). These errors happened when students failed to interpret what the problem was asking. For example, Subject S10 misinterpreted the instruction *"add the heights with even numbers"*, thinking it meant to sum the heights of students whose height values were even, rather than students with even roll numbers. This reflects low semantic reasoning and poor contextual understanding in HOTS problems (Sa'adah et al., 2019).
3. Transformation Errors
   Transformation errors were experienced by six students (S1, S3, S5, S7, S8, S9). These errors occurred when students were unable to convert the information in the problem into an appropriate mathematical model. For example, although Subject S1 understood the problem, they failed to transform the height information into a correct ratio. This indicates limitations in abstract thinking and the process of mathematization (Rahmawati, 2020).
4. Process Skills Errors
   Process errors were found in seven students (S1, S2, S5, S6, S8, S9, S10). These include mistakes in performing calculations or selecting the correct procedures. For instance, Subject S6 understood the problem and performed the transformation correctly but made a mistake when adding two decimal numbers. This indicates weak basic

computation skills despite a good conceptual understanding (Widodo & Wibowo, 2020).

5. Encoding (Answer Writing) Errors
   Answer writing errors occurred in six students (S2, S3, S5, S7, S8, S9). These errors relate to incomplete final answers, incorrect notations, or illogical responses. For example, Subject S5 completed all steps correctly but wrote the unit inconsistently, leading to a misinterpretation of the final answer. According to Newman (1983), even if previous stages are correct, an improperly formatted final answer still indicates a failure in mathematical communication.
6. Think Aloud Findings
   Think aloud data reinforced the TPMMH results, showing that many students were hesitant in identifying key information. For instance, Subject S6 repeatedly read the problem without a clear strategy, indicating weak metacognitive skills. Subject S3 expressed, *"maybe I can just add this directly"*, showing a tendency to rely on intuition rather than systematic mathematical procedures. This aligns with the findings of Santos & Pinto (2021), who noted that logical and heuristic errors frequently occur in solving HOTS problems.
7. Semi-Structured Interview Results
   Interviews supported the identification of thinking errors by providing the students' subjective reasoning. For example, Subject S10 stated: *"I thought even numbers meant the height values were even, not the student number."* This confirms misunderstandings in both comprehension and terminology. Subject S7 said, *"I was confused about where to start,"* indicating a failure in the transformation stage. The interviews also revealed that low-ability students were less familiar with HOTS-type problems and felt more comfortable with routine procedural questions.
8. Analysis Based on Ability Levels

Tabel 2. Number of Errors Based on Ability Category

Ability	Reading	Comprehension	Transformation	Process	Encoding (Answer Writing)
High	0	1	2	2	1
Medium	1	3	3	3	3
Low	2	2	1	2	1

From the table above, it can be concluded that:

a) High-ability students tend to make errors only in the transformation and process stages.
b) Medium-ability students exhibit errors across almost all categories, particularly in comprehension and answer writing.
c) Low-ability students often make reading and comprehension errors.

These findings reinforce the results of Rachmadi & Mustaji (2019), which state that thinking errors are more commonly found in students who are not accustomed to HOTS-based questions and whose learning habits focus solely on outcomes rather than the learning process.

The following section presents a discussion and analysis of the study, based on the research focus concerning the analysis of student errors in solving HOTS-based mathematical problems using Newman's Error Analysis. The research results are discussed in detail across the five types of errors, as follows:

a. Reading Errors

Reading errors were identified in students S1 and S2. These students failed to understand mathematical terms in the problem, missed important information, and became confused due to the length and complexity of the questions. These initial misinterpretations led to further errors in comprehension, transformation, and ultimately in answer writing. In the context of higher-order thinking (C4), such errors reflect weak initial analytical ability. According to Anderson, reading ability belongs to the lowest cognitive level (L1), but it is critical as it serves as the foundation for subsequent cognitive processes.

Reading errors often occur among low-achieving students (Singh et al., 2010), primarily due to limited reading habits from an early age (Burny et al., 2015). These students struggle to connect information within mathematical problems, which differs significantly from reading narrative texts. Fatahillah et al. further add that the habit of reading hastily and poor analytical skills also contribute to the occurrence of reading errors.

The main causes of reading errors include:

1. Lack of understanding of mathematical terminology
2. Ambiguity in the wording of questions
3. Confusingly long information
4. Low initial analytical ability of students

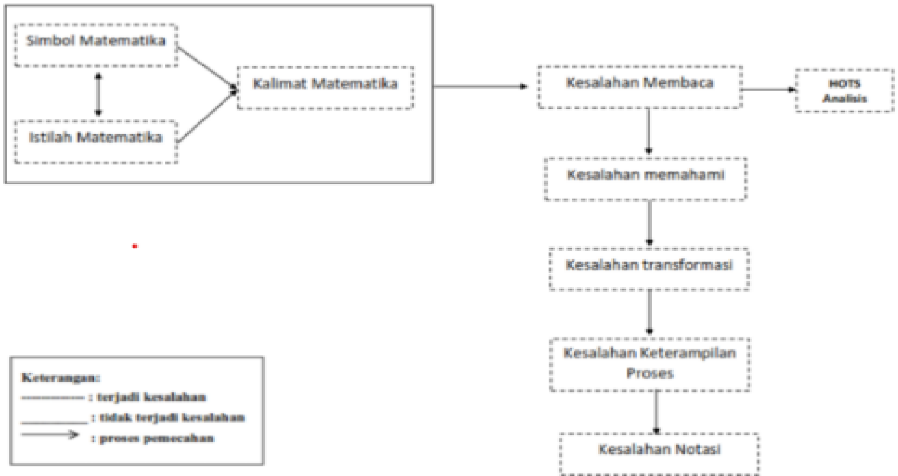

Figure 1. Student Reading Error Analysis

b. Misunderstanding

S3 and S4 made comprehension errors, namely failing to interpret information or writing it incorrectly. Despite being able to read well, they immediately answered without proper procedures and wrote incorrect mathematical sentences. In Anderson's taxonomy, this reflects weak evaluation skills (C5).

According to Wijaya et al. (2014), many Indonesian students struggle to solve HOTS problems because they are not used to contextual problems that require in-depth understanding. This is also supported by Abdullah et al. (2015), who stated that students have difficulty connecting information with problem-solving strategies.

Causes of comprehension errors include: (1) lack of ability to identify information, (2) inability to formulate mathematical sentences from data, (3) errors in determining important information, (4) poor reasoning skills, and (5) unfamiliarity with solving contextual problems.

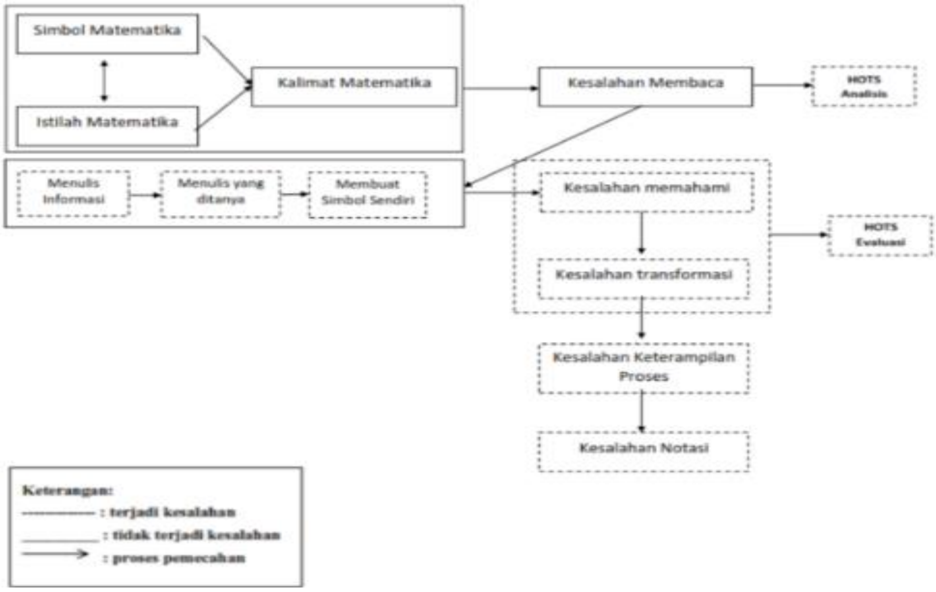

Figure 2. Analysis of students' errors in understanding

c. Transformation Error

S5 and S6 performed transformation errors. They understood the information in the problem but made errors in writing the mathematical model. Errors occurred due to carelessness or failure to convert units, as well as an inability to determine the appropriate mathematical strategy or operation.

Transformation errors reflect low evaluation skills (C5). According to Rismawati (2016), students experience these errors because they cannot communicate ideas into mathematical models. Melinda and Margareta (2019) added that this is often due to students not knowing the appropriate strategy or formula.

Causes of transformation errors include: (1) difficulty translating information into mathematical sentences, (2) confusion in determining strategies/formulas due to too-fast learning, and (3) lack of practice solving contextual word problems.

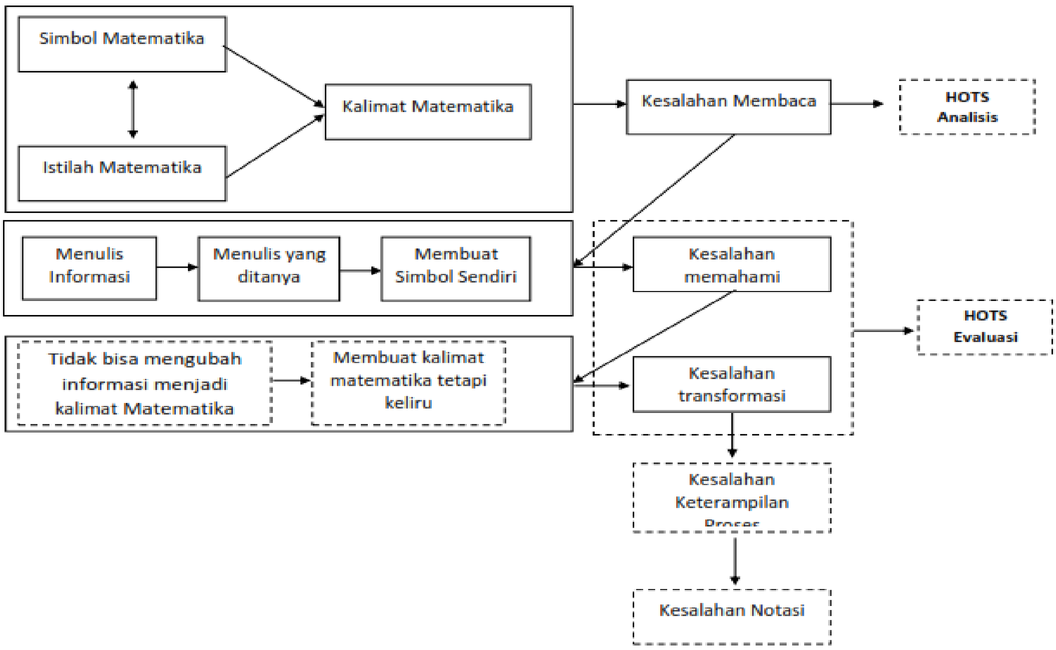

Figure 3. Analysis of student errors in transformation

d. Process Skills Errors

Students in grades 7 and 8 made errors during the process, particularly in arithmetic operations such as addition, subtraction, multiplication, and division. Although they understood the problem and were able to transform information, they failed to obtain the correct result due to carelessness in their calculations. These errors fall within the C6 (creative) level of the thinking taxonomy.

Sa'adah et al. (2019) identified carelessness as the primary cause of process errors, while Dharma et al. (2016) revealed that many students experienced calculation difficulties due to limited computational skills. These findings are consistent in this study, particularly in the context of decimal fractions.

Causes of process skill errors include: (1) poor arithmetic skills, (2) unfamiliarity with using procedures for word problems, and (3) lack of practice in HOTS-based mathematical problem-solving.

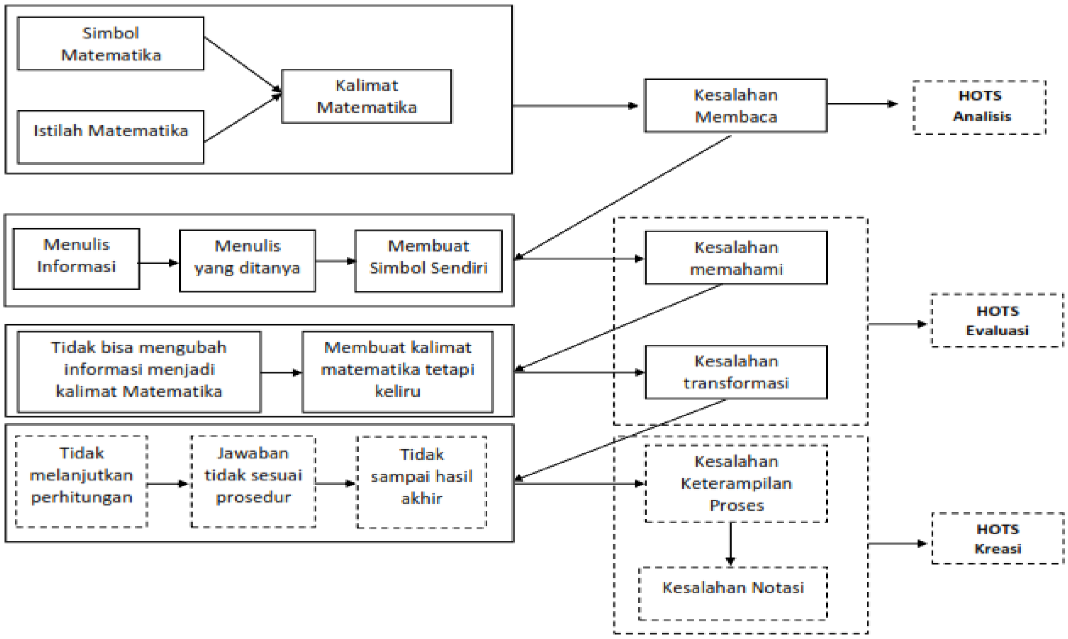

Figure 4. Analysis of student errors in process skills

e. Mistakes in Writing Answers

Errors in answer writing or encoding were found in S9 and S10. They did not write the final result correctly, such as using the wrong units, not writing a conclusion, or not answering according to context. This indicates a lack of habit of double-checking answers.

This error occurred at level C6, where students failed to encode the answer according to the question's requirements. Mariyati et al. (2018) stated that errors in the final stage often occur due to inaccuracy and a lack of habit of reviewing work. Suhita et al. (2016) added that the inability to draw conclusions is a significant factor.

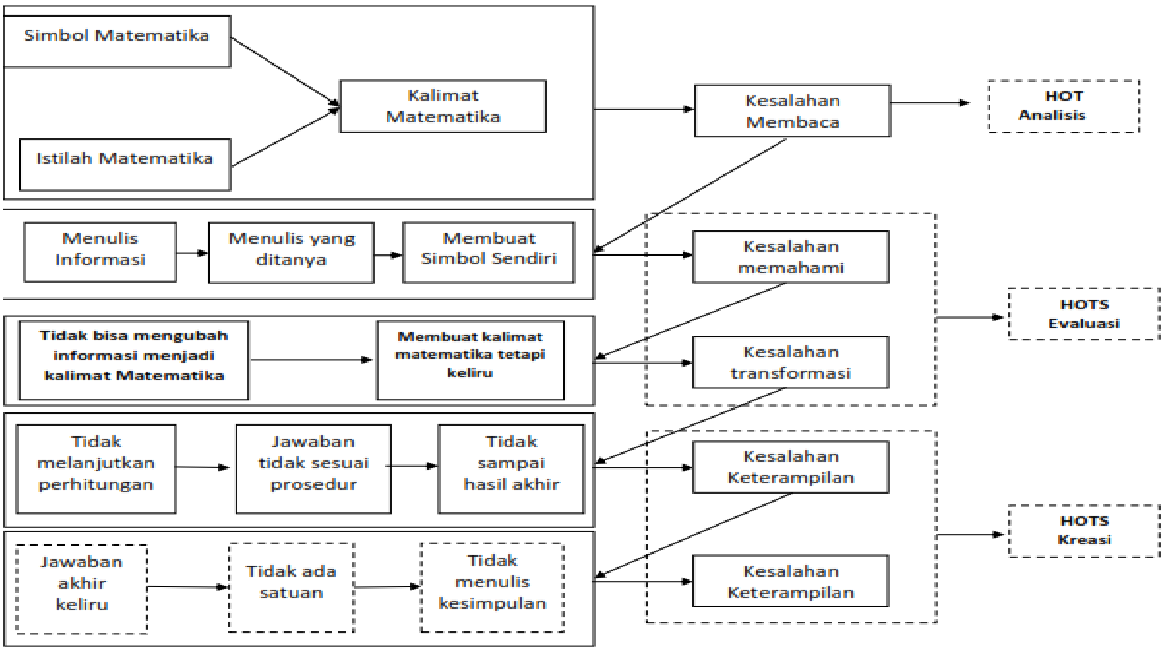

Figure 5. Analysis of student errors in writing final answers

Causes of error in answer writing include: (1) inaccuracy or rushing, (2) poor ability to formulate a final solution, (3) weak final calculation skills, and (4) unfamiliarity with drawing conclusions.

Conclusion

Based on the discussion, it can be concluded that there are five types of thinking errors commonly made by students when solving HOTS-based mathematics problems at the junior high school level, according to Newman's analysis. First, reading errors occur when students don't understand the terms in the problem, don't capture important information, and experience confusion due to the problem being too long and complex. Second, comprehension errors occur when students are unable to accurately write or interpret the information contained in the problem, even in some cases, writing incorrect information. Third, transformation errors occur when students are actually able to understand the problem information and know what is known and what is being asked, but they make mistakes in writing mathematical sentences or models, usually caused by carelessness or missing some important information. Fourth, process skill errors occur when students make errors in calculations, such as subtraction, addition, multiplication, or division, particularly in the context of decimal fractions. Inaccuracy in calculation is a dominant factor in these errors, resulting in incorrect final answers. Finally, errors in answer writing or notation occurred when students failed to change units as requested by the question, failed to include units in their answers, or failed to write conclusions that aligned with the question. These five types of errors indicate that students' thinking skills in solving HOTS-based math problems still need improvement, particularly in terms of understanding, accuracy, and the application of appropriate solution procedures.

References

Aryani Dan Maulida, 2019.Analisis Kesalahan Siswa Dalam Menyelesaikan Soal Matematika Melalui Higher Order Thinking Skill (HOTS), Jurnal Serambi Ilmu Volume 20, No.2. Edisi September 2019

Budiman, Agus & Jailani. "Pengembangan Instrumen Asesmen Higher Order Thinking Skills (HOTS) pada Mata Pelajaran

Matematika SMP Kelas VIII Semester 1", Jurnal Riset Pendidikan Matematika, Volume 1, Nomor 2, 2014.

Elise Burny, PhD, 1 MartinValcke, PhD, 1 dan Annemie Desoete, PhD 1 (2015). Oclock Reading Underestimated Topic In Children With Matemathic Dificult. http://Journal Of Learning Disabilities. Universitas California San Diego, Juni. P.352

Fatahillah,A. Wati,W. Susanto. 2017. Analisis Kesalahan Siswa Dalam Menyelesaikan Soal Cerita Matematika Berdasarkan Tahapan Newman Bersta Betuk Scafolding Yang Diberikan. Jurnal kadikma, 8 (I):40-41

Jatmiko. (2018). Kesulitan Siswa Dalam Memahami Masalah Matematika.JIP Mat. 3 (1) https://doi.org/10.26877/jipmat.v3i1.2285

Karnasih, Ida (2015). Analisis Kesalahan Newman Pada Soal Cerita Matematis. Jurnal Paradikma FMIPA Unimed Medan 8 (1) p.37

Kemendiknas, 2017. Juknis PPK Dan Literasi Di Sekolah Tingkat Dasar Dan Menengah, Jakarta.

Kemendikbud, 2017. Silabus Mata Pelajaran Matematika SD/MI, Depdikbud: Jakarta.

Kemendikbud, 2019. Buku Penialian Berorientasi Hingher Order Thinking Skills. Jakarta: Direktorat Jendral Guru Dan Tenaga Kependidkan Kemendikbud

Kemendikbud, 2017. Silabus Mata Pelajaran Matematika SMP/MTs, Depdikbud: Jakarta.

Kurniadi, dkk. 2018. Kesalahan Siswa Pada Kategori Keampuan Awal Matematis Rendah Dalam Penyelesaian Tes Kemampuan Pemecahan Masalah Matematis. Jurnal Penelitian Dan Pembelajaran Matematika. Vol.11 No.2.

Layn R.M Dan Kahar, S, M. 2017. Analisis Keslahan Siswa Dalam Menyelesaikan Soal Cerita Matematika. Jurnal Math Educator Nusantara (JMEN). 03(2), Pp59-84

Mainali, 2012.Hinger Order thinking in educations. A mutidiciplinary jurnal (2) 5-7

Mansur, dkk. 2017. Al qur'an Basec Learning Stratrgy In Teaching Mathematics At Primary Education. Advences In Sosial Scienec, Education And Humanities Research. 168.P.304-306

Maya Mulyani Dan Dedi Muhtadi, 2019. Analisis Kesalahan Siswa Dalam Meyelesaikan Soal Trigonometri Tipe Hinger Order Thinking Skill Ditinjau Dari Gender. JPPM, Vol. 1.

Melinda,R Dan Margareta A. (2019). Analisis Kesalahan Konsep Siswa Dalam Menyelesaikan Soal Ulangan Matematika Dengan Metode Newman. STKIP Persada Khatulistiwa Sintang. Jurnal Pitmat. Vol. 1. P74

Moleong, Lexy J.2012. Metodologi Penelitian Kualitatif. Bandung: PT.Rosdakarya

NCTM, 2014 . Principles And Standart Forschool Mathematic. National Council Ot Teacher Of Matematic, 1-6

Rismawati, M. 2016. Mengembangkan Peran Matematika Sebagai Alat Berpikir Ilmiah Melalui Pembelajaran Lesson Study. Journal Vox Education, 7 (2).203-2015

Sa'adah, dkk. 2019. Analisis Kesalahan Dalam Menyelesaikan Soal Matematika HOTS Tipe PISA, Journal For Islamic Social Siencies , Volume 3 No. 1.

Sing P, Arba and Raeh Sian Hoon. (2010). The Newman Procedure For Analyzing Primary Four Pupils Errors On Writtenmatematichal Tasks:A Malaysian Perspective. International Converence On Matemathic Education Research 2010 (ICMER 2010) Pp1877-0428

Soedjadi. 2000. Kiat Pendidikan Matematika Indonesia. Jakarta: Depdiknas

Subadar, "Penguatan Pendidikan Karakter (PPK) Berbasis Higher Order Thinking Skills

(HOTS)", Jurnal Pedagogik, Vol. 4, No. 1, 2017.

Sugiyono (2016). Metode Penelitian Kuantitatif, Kualitatif, Dan R&D, Bandung: Alfabeta

Widana, I.W. 2017. Penyusunan Soal Hinger Order Thinking Skill (HOTS), Jakarta: Direktorat Jendral Pendidikan

Wijaya.A,Panhuizen,M.H.Doorman,M. & Robitzsch,A.(2014). Difficulties In Solving Contex Based PISA Mahtematics Tasks: An Analysis Of Student Errors. TME.30.P.580