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NEWMAN'S ERROR ANALYSIS ON JUNIOR HIGH SCHOOL STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY IN THE PYTHAGOREAN THEOREM

Aisyah Muthia Ghefira[1*], Al Jupri[2]
[1,2]Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
*Correspondence: aisyahmggl@upi.edu

ABSTRACT
This study aims to identify students' errors in mathematical problem-solving based on Newman's Error Analysis (NEA) framework through a qualitative descriptive method. The subjects were 27 eighth-grade students of SMP Negeri 10 Palembang, selected as one intact class to represent common student errors in the learning process. Data were collected using a problem-solving test on the Pythagorean Theorem and interviews, with instruments tested for validity, reliability, difficulty level, and item discrimination. The focus on the Pythagorean Theorem is crucial as it is a foundational topic in junior high school mathematics that supports students' understanding of geometry, logical reasoning, and higher-level problem-solving. The results show that the most frequent errors occurred in developing solution plans and rechecking answers, while dominant errors in NEA categories were transformation, process skills, and encoding. These findings highlight students' difficulties in fully understanding problem-solving procedures and provide valuable insights for teachers to design more targeted learning strategies. Practical recommendations include emphasizing problem comprehension, strengthening basic calculation skills, guiding students in problem transformation, and fostering reflective practices such as self-checking, which can help reduce errors and enhance students' conceptual understanding of mathematics.
Keywords: Mathematical Problem-Solving Ability, Newman's Error Analysis, Pythagorean Theorem.

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PRELIMINARY

Mathematics learning is one of the essential aspects of education because it aims to enhance the potential and quality of each individual (Jannah & Hayati, 2024). Mathematics is considered the gateway to other sciences, as mathematics is the queen and servant of all sciences (Anggara & Solahudin, 2022). Mathematics not only plays a role in mastering knowledge and skills but also in shaping mentality, logical thinking patterns, and the ability to apply concepts in everyday life (Insani, 2019). Furthermore, mathematics functions as a means of thinking, a tool for solving complex problems, a medium to recognize patterns and relationships, as well as a platform for developing creativity and cultural awareness (Halim & Rasidah, 2019).

At the national level, the mathematics achievement of Indonesian junior high school students still presents significant challenges. The PISA 2022 results showed that Indonesia's average mathematics score was 366, far below the global average of 472 (Latifah, & Kismiantini, 2025). Similarly, in the TIMSS study, Indonesian eighth-grade students consistently scored below the international average; for instance, in 2011 Indonesia scored 386, while the international average was around 500 (Nurfaidah, Pasani, & Sari, 2023). These data highlight that Indonesian students' mathematical abilities remain relatively low, particularly in applying concepts and solving complex problems. Therefore, research that identifies students' errors, such as through analysis based on Newman's Error Analysis (NEA), is crucial to strengthening the quality of mathematics learning.

The essence of mathematics is closely related to problem-solving (Duha & Harefa, 2024). The process of problem-solving begins with recognizing contextual problems, understanding relevant concepts, and applying those concepts to find solutions (Ayuningsih et al., 2025). Problem-solving ability is one of the key indicators of successful mathematics learning because it reflects how far students can connect knowledge with practice (Aziz et al., 2025). In this context, students are required not only to master concepts theoretically but also to be able to apply them in solving real-life problems.

One of the topics that demand problem-solving skills is the Pythagorean Theorem. This topic is taught at the junior high school level and serves as the foundation for various other topics in geometry. The Pythagorean Theorem is closely related to everyday life, such as in determining distance, height, and applications in engineering and science (Maor, 2019). However, in reality, many students still struggle to understand the concept and apply the theorem to solve problems (Khoerunnisa & Sari, 2021). Errors that arise are not only in the final results but also in the thinking process, starting from reading the problem, understanding the question, selecting strategies, to writing the final answer.

This phenomenon indicates that each student has different characteristics in the problem-solving process (Zulfah et al., 2019). In line with (Agustina , 2016), errors may occur even though students understand the solution steps but fail in application or calculation. Therefore, it is crucial to identify the types of errors in more detail so that teachers can pinpoint where students encounter difficulties. Such error analysis not only helps teachers improve the learning process but also benefits students in recognizing their weaknesses and enhancing mathematical thinking skills.

Based on a preliminary study conducted at SMP Negeri 10 Palembang in grade VIII mathematics learning, it was found that many students still made mistakes in answering practice and test questions. This condition shows that students' conceptual understanding and mathematical procedural application are not yet fully optimal. Considering the importance of mastering concepts in mathematics learning and the lack of in-depth identification of student errors, a systematic analysis is needed to reveal the root of these problems, particularly in topics like social arithmetic, which are closely related to daily life.

One approach that can be used to identify student errors is Newman's Error Analysis (NEA). Newman's theory is a technique designed to analyze and understand the types of errors students experience when solving problem-solving tasks (Yusnia & Fitriyani, 2010). Through NEA, teachers can trace students' thinking stages in more detail, not only determining whether answers are right or wrong but also identifying at which stage the errors occur.

According to Newman (1977), there are five types of errors that can be identified: (1) reading errors, (2) comprehension errors, (3) transformation errors, (4) process skill errors, and (5) encoding errors. With this classification, teachers can map students' weaknesses more accurately.

Research conducted by (Ashari et al., 2023) revealed that students' difficulties in solving mathematical word problems based on Newman's Error Analysis include all stages: reading, comprehension, transformation, process skills, and encoding. Students in the high category generally experience difficulties only in transformation, process skills, and encoding, while students in the medium and low categories struggle at all stages. This emphasizes that weaknesses in the early stages, such as reading and comprehension, can impact errors in later stages, thus requiring learning strategies that focus more on comprehensive understanding and problem-solving skills.

Another study conducted by (Sumargiyani et al., 2020) showed that the results of analysis using NEA could provide positive implications in learning, including helping teachers improve the effectiveness of the learning process, select appropriate methods and strategies, and reduce the number of student errors in solving problems. Therefore, the application of NEA to social arithmetic material is an important step in evaluating students' mathematical problem-solving abilities while providing a foundation for developing more targeted learning strategies.

Based on these explanations, research on *"Newman's Error Analysis (NEA) on Junior High School Students' Mathematical Problem-Solving Ability in the Pythagorean Theorem"* needs to be conducted. This study is expected to provide a clear overview of the types of errors made by students, thus serving as a foundation for teachers in designing more effective learning strategies. Practically, the findings can help teachers identify which stages of problem-solving—such as comprehension, transformation, or process skills—require greater attention, so that remedial teaching and scaffolding can be directed more precisely. For students, this research provides insight into their own weaknesses, encouraging them to develop metacognitive skills such as self-monitoring and rechecking their work. In terms of application, the results of this study can be integrated into Pythagorean Theorem learning strategies by providing more structured practice in transforming word problems into mathematical models, offering step-by-step guidance in calculations, and incorporating reflective activities to strengthen rechecking skills. Through these targeted instructional improvements, students' mathematical problem-solving abilities—particularly in applying the Pythagorean Theorem—can be enhanced more effectively and sustainably.

METHODS

This research employs a descriptive qualitative approach. Qualitative research is descriptive in nature (Rukin, 2019) and aims to provide an in-depth description of the types of errors made by students in solving mathematics problems on social arithmetic material based on Newman's Error Analysis (NEA). The study was conducted at SMP Negeri 10 Palembang with the subjects being Grade VIII students in the 2025 academic year, totaling 27 students. From this group, five students were selected for in-depth interviews, as they showed the highest number of errors in completing the posttest. The objects of this study were students' posttest answers and interview data.

The main instrument used in this research was a posttest that was administered after the learning process. The posttest was designed not only to measure students' mathematical problem-solving ability but also to identify the types of errors made. The test was developed based on four indicators of mathematical problem-solving ability, namely understanding the problem, developing a solution plan, performing calculations, and rechecking the solution. Students' abilities were further categorized into five levels according to the percentage of correct answers: very low (0%–20%), low (21%–40%), moderate (41%–60%), high (61%–80%), and very high (81%–100%).

In analyzing students' answers, this research employed Newman's Error Analysis (NEA) procedure. NEA is a framework introduced by Newman (1977) which explains that when solving word problems, students go through five cognitive stages: reading, comprehending, transforming, processing, and encoding. Errors may occur at any of these stages. Reading errors occur when students fail to read or recognize mathematical symbols, numbers, or terms correctly. Comprehension errors occur when students read the problem but do not understand what is being asked. Transformation errors arise when students understand the problem but cannot convert it into the correct mathematical form. Process skill errors take place when students select an appropriate strategy but perform incorrect calculations or operations. Finally, encoding errors occur when students obtain the correct result but fail to write the final answer correctly or in the required form.

The implementation of NEA in this research was carried out systematically. Each student's posttest answer sheet was analyzed step by step according to the five NEA categories. Errors were identified and recorded for every item, then classified into the corresponding error type. The frequency of each error type was calculated and converted into percentages to provide a clearer description of the distribution of errors. Furthermore, five selected students were interviewed to validate the underlying causes of their mistakes and to confirm the consistency between written answers and the difficulties they actually experienced.

Data collection techniques in this study consisted of observation, posttest, and interviews. Open observation was conducted in the classroom to understand the mathematics learning process and to ensure that the problems given were in line with the junior high school curriculum standards. The posttest served as the main instrument to measure students' problem-solving ability and to analyze their errors through NEA. Semi-structured interviews were then carried out with selected students to explore their understanding, experiences, and difficulties in solving problems, while also serving as complementary data to strengthen the findings from the posttest.

The data analysis process involved three stages. First, data reduction was conducted by selecting, simplifying, and focusing on important data in accordance with the research objectives. Second, data display was carried out by presenting the findings in narrative and tabular forms. Finally, conclusion drawing was performed by formulating the research findings regarding the types of errors students made and their level of problem-solving ability. To ensure data validity, source triangulation was applied by comparing posttest results with interview data so that the findings were more valid and accountable.

RESULT AND DISCUSSION

The research data were obtained through the administration of a posttest conducted after the learning process. The posttest was designed to measure the level of students' mathematical problem-solving ability based on predetermined indicators. The posttest results were then analyzed to determine the extent to which students were able to understand concepts, develop solution strategies, and provide correct final answers. The following presents the percentage results of the posttest on junior high school students' mathematical problem-solving ability.

Table 1. Percentage of Junior High School Students' Mathematical Problem-Solving Ability Posttest

No	Indicators of Mathematical Problem-Solving Ability	presentasi	
		n	%
1	Understanding	7	26
2	Performing Calculations	4	15
3	Develoving a Solution Plan	1	4
4	Rechecking	5	19
Total		27	100

Based on Table 1 regarding the percentage of junior high school students' mathematical problem-solving ability posttest, it can be seen that the indicator of understanding the problem obtained the highest percentage, namely 26% (7 students). This indicates that some students were able to identify the information contained in the problem, although the number is still relatively low compared to the total number of students who took the test. According to Fuchs et al. (2019), reading and interpreting the text of a problem is a key component that mediates the success of solving mathematical problems. Thus, if students do not possess this key understanding, they will encounter difficulties in solving mathematical problems.

For the indicator of rechecking, 19% (5 students) were able to perform this step. This means that only a small proportion of students had the awareness to review their problem-solving steps and final answers. Meanwhile, for the indicator of performing calculations, only 15% (4 students) were able to complete the calculations correctly. This condition indicates that students' procedural skills are still low, particularly in applying mathematical concepts accurately. The indicator with the lowest achievement is developing a solution plan, which only reached 4% (1 student). This finding shows that the majority of students have not yet been able to design a systematic solution strategy before moving on to the calculation stage. Thus, the greatest weakness of students lies in their ability to plan solution steps and connect them with relevant mathematical procedures.

Overall, the results of this posttest show that students' mathematical problem-solving ability is still in the low category. Most students experienced difficulties, particularly in the stages of planning strategies, process skills, and rechecking answers, which had implications for their inability to arrive at the correct final solution. This is in line with the findings of other studies that student errors often occur in the stages of transformation, process skills, and encoding of the final answer.

Based on the analysis of students' answers on the test sheets, various types of errors were identified in accordance with Newman's Error Analysis (NEA) procedure. These errors include reading errors, comprehension errors, transformation errors, process skill errors, and encoding errors. To provide a clearer picture of the distribution of student errors, the following section presents a recapitulation of the percentage of each type of error.

Table 2. Recapitulation of Student Error Percentages

Type of Error	Problem Number				Total	%
	1	2	3	4		
Reading Errors	8	11	15	13	47	17.4
Comprehension Errors	11	14	17	18	60	22.2
Transformation Errors	17	17	18	18	70	25.9
Process Skill Errors	21	21	21	26	89	33.0
Encoding Errors	21	21	25	26	93	34.4

Based on Table 2 regarding the recapitulation of student error percentages in solving mathematical problem-solving tasks, it can be seen that the most dominant type of error is encoding errors (final answer errors) with a percentage of 34.4% (93 errors). This indicates that many students carried out the problem-solving steps but were less careful in presenting the final result, either due to writing mistakes, minor arithmetic errors, or inconsistencies with the required answer format.

Another relatively high error type is process skill errors, with a percentage of 33.0% (89 errors). This finding suggests that students still experience difficulties in performing calculations or correct mathematical procedures, so the process leading to the final answer does not follow the expected concepts.

Furthermore, transformation errors reached 25.9% (70 errors). These errors occur when students fail to convert information from word problems into the correct mathematical model, for example by writing the wrong equation or choosing an inappropriate formula.

Meanwhile, comprehension errors were found at 22.2% (60 errors). This shows that some students still struggle to understand the meaning of the problem, including identifying important information and what is being asked. The lowest percentage of errors was reading errors, at 17.4% (47 errors). This means that most students did not face significant difficulties in reading the problem text, but more errors appeared in the subsequent stages, namely comprehension, transformation, and processing of information.

Overall, this analysis shows that students' main weaknesses lie in the process skills stage and final answer writing, which implies their low ability to arrive at the correct mathematical solution. This is in line with the study conducted by (Azmi et al., 2024), whose results showed that the most frequent errors were in final answer writing, with a percentage of 27.02%. Thus, teachers need to pay more attention to learning that emphasizes procedural accuracy, computational skills, and strategies for presenting the final answer, in addition to strengthening the understanding of basic concepts.

These results indicate that students still make many errors in the stages of transformation, process skills, and final answer writing. This means that the indicators of mathematical problem-solving ability have not been fully achieved. Therefore, the following section will present students' answers along with the analysis using Newman's Error Analysis (NEA).

a. Reading Error

The test result of Subject 19 in solving the mathematics problem on Question Number 2 is as follows:

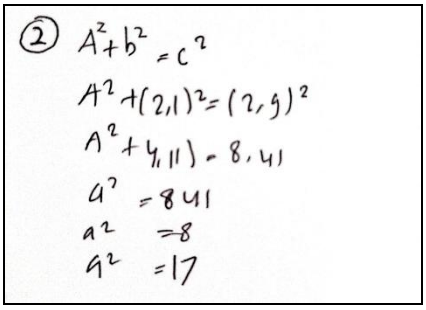

Figure 1. Test Result of Question Number 2 from Subject 19

Based on Figure 1, the field research results show that Subject 19 experienced a reading error. This can be seen from the inability to read the problem correctly and the failure to identify the given figure. The interview results also supported this finding, where the subject admitted that he/she was not yet fluent in reading, thus having difficulty understanding the basic information written in the problem. This condition indicates that limitations in reading skills can become an initial obstacle in the process of mathematical problem-solving, as students are unable to grasp the information that should be used in the next stage.

b. Comprehension Error

The test result of Subject 4 in solving the mathematics problem on Question Number 1 is as follows:

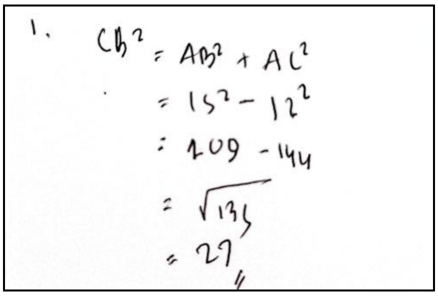

Figure 2. Test Result of Question Number 1 from Subject 4

Based on Figure 2, the field research results show that Subject 4 demonstrated a comprehension error. This error was evident from the inability to write down what was known and what was asked in the problem. The interview results also reinforced this finding, where the subject was unable to mention the important information contained in the problem, and even provided only partial information. This condition indicates that the subject experienced difficulties in identifying the basic elements of the problem, thus being unable to continue the problem-solving process to the next stage. Therefore, the weakness at the comprehension stage becomes a significant obstacle that directly affects the student's success in solving mathematical problems.

c. Transformation Error

The test result of Subject 4 in solving the mathematics problem on Question Number 2 is as follows:

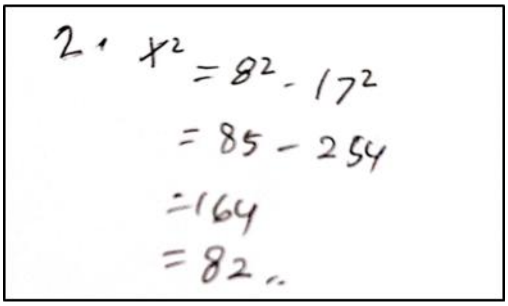

Figure 3. Test Result of Question Number 2 from Subject 4

Based on Figure 3, the test results show that Subject 4 made a transformation error. This error can be seen from the inability to correctly write the Pythagorean formula. The subject wrote the letters in the formula randomly and not according to the correct notation, which led to an incorrect solution procedure. The interview results also support this finding, where the subject was unable to state the Pythagorean formula accurately when asked to explain it again. This indicates that the subject experienced obstacles in transforming the information from the problem into the correct mathematical model, resulting in a solution strategy that did not align with the appropriate concept.

d. Process Skill Error

The test result of Subject 23 in solving the mathematics problem on Question Number 3 is as follows:

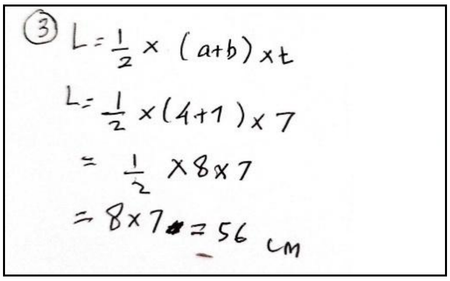

Figure 4. Test Result of Question Number 3 from Subject 23

Based on Figure 4, the field research results show that Subject 23 made a process skill error. This error is evident from the inability to complete the calculation correctly, resulting in an incomplete answer. The interview results also reinforced this finding, where the subject not only made mistakes in the calculation procedure but also failed to explain the calculation steps used accurately. This condition indicates that the subject is still weak in procedural skills, namely in applying mathematical concepts and operations correctly to reach a solution. Thus, obstacles in the process skill stage become one of the significant factors in students' failure to solve mathematical problems optimally.

e. Encoding Error

The test result of Subject 23 in solving the mathematics problem on Question Number 4 is as follows:

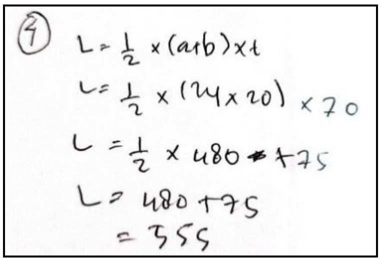

Figure 5. Test Result of Question Number 4 from Subject S23

Based on Figure 5, the field research results show that Subject 23 made an encoding error. This error appeared at the conclusion stage, where the subject did not write the final answer at all. This finding was reinforced by the interview results, which revealed that the subject not only failed to provide a conclusion but also did not include the unit that should have accompanied the calculation result. This condition illustrates that although the subject may have gone through several stages of problem-solving, the weakness in presenting the final answer caused the solution to be unassessable. Thus, obstacles at the encoding stage indicate that some students are still less meticulous and not accustomed to writing the final conclusion systematically, completely, and in accordance with mathematical conventions.

The most frequent error occurred in the aspect of encoding, with a percentage of 34.4%. This indicates that most students were able to perform the solving process but were still careless in writing the final conclusion along with its unit. As a result, the answers obtained became incomplete and could not be categorized as correct. This finding is consistent with previous studies, which stated that students often neglect the final stage in problem-solving, leading to final results that do not align with the expected solution procedure.

The next most dominant error was in the aspect of process skills, with a percentage of 33.0%. This shows that many students are not yet skilled in performing calculations correctly. This finding is in line with the research conducted by (Fitria & Rismawati, 2024), whose study showed that process skill errors often arise due to students' lack of arithmetic skills and accuracy. (White, 2009) also emphasized that process skill errors occur when students fail to apply the correct calculation procedures, even though they understand the problem and can select the correct formula. Calculation errors directly affect the inaccuracy of the final result, even if the problem comprehension and formula transformation have been done properly. This condition highlights that students' procedural skills still need to be improved through intensive practice and reinforcement of basic concepts.

Meanwhile, transformation errors also appeared quite frequently, with a percentage of 25.9%. These errors occurred because students were unable to write the formula correctly or chose the wrong solving strategy. This shows a weakness in connecting the problem information into the correct mathematical form. Mathematical representation skills thus become an important aspect that must be strengthened, as they serve as a bridge between problem comprehension and calculation processes.

Comprehension errors, with a percentage of 22.2%, revealed that some students were still unable to write down the information given and asked in the problem. This indicates that students' mathematical reading comprehension skills still need to be developed, especially in identifying the core issue in word problems. Lastly, although the percentage is the lowest, reading errors, with 17.4%, remain a problem that cannot be ignored. Some students struggled to read the problem correctly, including identifying symbols or diagrams within the problem. Reading fluency and understanding of mathematical terms strongly affect this type of error.

Overall, the results of this study show that students still face obstacles in almost all stages of problem-solving according to Newman's procedure. The most significant errors were found in the final stages of problem-solving, namely in process skills and encoding. This indicates that while students' ability to understand the problem and transform it into a mathematical form is relatively good, they are still weak in carrying out calculations and formulating the correct and complete final answers. Recent studies corroborate this pattern: for example, (Ahzan et al., 2022) found that eighth-grade students had very high encoding errors (86.67 %) and process skills errors (71.11 %) using the NEA framework. Similarly, in a 2024 study by Iilonga & Chirimbana, transformation and process skills errors were each observed in about 62 % of students, and encoding errors in about 62.8 %. These findings underline that the later stages of problem-solving (calculation, execution, and final answer writing) remain critical trouble spots.

The low ability of students in solving mathematical problems is inseparable from several influencing factors. The findings of (Sartika et al., 2024) revealed that the causes of student errors consist of both internal and external factors. These include students who dislike mathematics, find it difficult to concentrate while learning, face challenges in reading, have limited understanding of mathematical symbols, and rarely participate in learning activities. Such external factors directly impact students' lack of skills in both understanding problems and solving calculations correctly.

In addition to these external factors, interview and observation results with mathematics teachers also highlighted internal factors influencing students' low performance. Some students come from broken home families, thus receiving little support and motivation for learning from their home environment. Furthermore, there are students with physical conditions such as autism, who tend to be absorbed in their own world, making it difficult for them to focus on the learning process. These internal factors further reinforce the reasons behind students' low ability in solving mathematics problems, including in the context of applying the Pythagorean Theorem.

CONCLUSION

Based on the research findings, it can be concluded that junior high school students still make many errors in mathematical problem-solving, particularly in the indicators of planning a solution and re-checking the final result. Viewed from Newman's Error Analysis (NEA), the most dominant errors are transformation errors, process skill errors, and encoding errors in writing the final answer. This condition shows that most students have not yet been able to follow the steps of problem-solving in a sequential and systematic manner. In addition, the low problem-solving ability of students is influenced by several factors, both external and internal. External factors include a lack of interest in learning mathematics, difficulty concentrating, reading obstacles, weak mastery of mathematical symbols, and irregular attendance in class. Internal factors include family conditions such as broken homes and physical or developmental disorders such as autism, which cause students to be less focused during the learning process.

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