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Integrating Error Analysis Strategy in Developing Students' Ability in Solving Non-Routine Problems

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Abstract
Aim: This study aimed to improve students' problem-solving abilities using an error analysis approach and explore the errors made by students and the factors contributing to these errors when solving non-routine problems.
Methodology: The research employed a mixed-method design and cluster sampling to select participants. One section of Grade 9 students from a public secondary school, consisting of 29 diverse learners, took part in the study. Data collection involved tests, interviews, and the implementation of lesson exemplars integrating the error analysis strategy.
Results: The findings indicated a significant improvement in the students' problem-solving ability level when the error analysis strategy was applied. Initially, reading errors and transformation errors were the most common errors committed by the students while encoding errors after the integration of the strategy. Furthermore, it was found that the lack of understanding, misconceptions, carelessness, lack of mastery, and compounding errors were the factors contributing to the errors committed by the students in solving non-routine problems in trigonometry.
Conclusion: There is a significant difference between the students' problem abilities before and after the integration of the error analysis strategy in solving non-routine problems in trigonometry. Hence, the researchers suggest teachers and students to utilize the error analysis strategy and give attention to encoding errors.

Keywords: Problem-solving Ability, Error Analysis Strategy, Non-Routine Problem

INTRODUCTION

Mathematics is a fundamental foundation of education, with problem-solving skills being fundamental for students' intellectual growth and future success. Problem-solving plays a vital role in various fields and daily life, as highlighted by Rayan (2019), and Ersoy (2016) emphasizes its importance in developing students' high level of thinking skills as most learning occurs because of the problem-solving process. Aligning with the primary goals of the K-12 program, as said by Alcantara and Bacsa (2017), the cultivation of mathematics problem-solving abilities must be given attention. The K to 12 Curriculum, established in the Philippines in the 2011-2012 academic year, aims to make education more relevant to students' daily experiences. Notably, it now prioritizes nurturing critical thinking and problem-solving skills in mathematics education, departing from the traditional view of memorization and equation-solving. This shift towards introducing Filipino students to non-routine real-world problems is expected to enhance their comprehension of mathematical concepts and algorithms, ultimately leading to a higher level of proficiency (Fortes & Andrade, 2019).

However, outcomes of standardized tests administered to students in the Philippines indicate that they do not meet the NTCM standards, which encompass the ability to grasp, persevere, and think quantitatively and abstractly when solving problems. This deficiency stems from a lack of understanding of technical terms, leading to context misinterpretation (Timario, 2020). Furthermore, it is observed that many students lack the necessary skills for addressing real-world problems beyond the classroom setting, primarily due to their training in dealing with routine, well-defined problems where all essential information is readily available (Legarde, 2022). Moreover, different studies and academic literature have shown that errors in mathematical problem-solving lead to poor

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mathematical problem-solving abilities. These errors often occur because students do not fully understand mathematical concepts, resulting in incorrect answers (Wahab et al., 2014; Huat, 2015 as cited in Thomas & Mahmud (2021).

Similarly, the Department of Education conducted the National Learning Camp during the school year vacation as part of the learning recovery due to the pandemic. It offers three camp options, including the consolidation camp, which serves students who need additional practice and application of previously taught competencies that are identified as least learned competencies. Most of the activities included in this camp are problem-solving, which aligns with Hortal's (2021) claim that problem-solving is one of the least learned competencies in Mathematics, regardless of grade. One of the researchers volunteered at the camp and observed several errors they committed in the process of problem-solving especially in non-routine ones which is why they could not arrive at the correct answer. Camp learners commonly face challenges in understanding the problem's context, constructing mathematical sentences, and lacking the necessary math skills for specific problem-solving. Some manage to arrive at the correct answer but still encounter minor errors due to carelessness, while others make mistakes at the very beginning, such as misreading the problem and just guessing the answer. Furthermore, for several years in teaching Mathematics, one of the researchers observed that students always get low scores and MPS and find trigonometry difficult especially in problem-solving. Several interventions such as remedial classes and peer tutoring were tried to improve the results in problem-solving in trigonometry were tried but still, they could not arrive at the desirable results. Trigonometry is one field of mathematics taught in high school that is considered by most students as difficult to master, understand, and learn (Aminudin et al., 2019, Anggraini & Putra, 2020; Tanu Wijaya et al., 2020).

Addressing errors promptly is crucial, as both Thomas and Mahmud (2021) and Sumule et al. (2018) stress that neglecting errors in early stages can significantly affect students' future math learning, emphasizing the importance of immediate attention and analysis to identify and correct these errors to prevent their impact on succeeding problem-solving. Analyzing the students' errors is necessary to understand how the students solve mathematical problems (Abenojar, 2024; Rohmah & Sutiarso, 2017) and it can help the students understand the problem well since they already know the errors and can already correct them (Chusnul et al., 2017). Moreover, Rushton (2018) claims that teaching mathematics through error analysis offers several advantages. It deepens students' understanding, enhances their ability to correct misconceptions, and promotes productive struggle and discussions. It also helps students identify and fix errors, making learning enjoyable. This approach fosters long-term knowledge retention and equips students with the lifelong skill of evaluating arguments and identifying flaws in reasoning, aligning with mathematical standards. The Error Analysis Strategy serves as a valuable tool because it models the analysis of mistakes as a learning opportunity and brings attention to common misconceptions (Creighton et al., 2015).

White (2010) as cited in Badriani et al. (2022) stated that the Newman error procedure or Newman's Error Analysis (NEA) is one method that can be used to analyze students' errors in solving mathematics problems. It has five stages: reading, comprehension, transformation, process skills, and encoding. Furthermore, Chusnul et al. (2017) added that the Newman procedure is widely used in identifying students' errors in problem-solving, it also provides an opportunity for excellent professional learning and creates a nice link between literacy and numeracy since it does just not analyze why the students make mistake but rather the results of the students' work from beginning to end. Sumule et al. (2018) also claimed that Newman's procedure has a framework that is easy to understand which allows teachers to find out the mistakes that students commit in solving problems.

Objectives

The purpose of this study was to analyze the students' errors in solving mathematical problems using Newman's procedure. Specifically, the researcher sought to answer the following questions:

1. What is the level of students' problem-solving abilities in solving non-routine mathematical problems in trigonometry before and after integrating the error analysis strategy?
2. What are the common students' errors in solving non-routine mathematical problems in trigonometry based on Newman's procedure?
3. What are the factors contributing to the students' errors in solving non-routine mathematical problems in trigonometry?
4. Is there a significant difference in the students' problem-solving abilities before and after integrating the error analysis strategy?

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Hypothesis

1. There is no significant difference in the students' reading ability before and after the integration of the error analysis strategy.
2. There is no significant difference in the students' comprehension ability before and after the integration of the error analysis strategy.
3. There is no significant difference in the students' transformation ability before and after the integration of the error analysis strategy.
4. There is no significant difference in the students' process skills ability before and after the integration of error analysis. strategy
5. There is no significant difference in the students' encoding ability before and after the integration of the error analysis strategy.

METHODS

Research Design

The mixed method research design, specifically the embedded design, was used in this study. It involves the combination of elements from both quantitative and qualitative research approaches to address a research inquiry. It provides a more holistic understanding than conducting solely quantitative or qualitative investigations, as it capitalizes on the advantages of both methodologies (George, 2023). Quantitative data was used to determine the level of students' problem-solving abilities and establish statistical significance in solving non-routine mathematical problems in trigonometry before and after using the error analysis strategy. On the other hand, qualitative methods were utilized to identify the common student errors and various factors contributing to the errors committed in solving non-routine mathematical problems in trigonometry, aligning with Newman's procedure.

Population and Sampling

The respondents of the study were Grade 9 students enrolled in the school year 2023-2024 from a public secondary school in the District of Padre Burgos. The researchers specifically selected Grade 9 students since they are the only grade level that includes trigonometry in the curriculum. They were selected from all sections of Grade 9 students through a cluster sampling technique applied to the entire population of Grade 9 students. All sections of Grade 9 were grouped heterogeneously. Cluster sampling employs randomization, and when the population is effectively clustered, the research will exhibit a strong degree of external validity. This is because the sample will accurately mirror the characteristics of the broader population (Thomas, 2023).

However, to determine the factors contributing to the errors committed by the students, six participants were purposively selected. These participants were the students selected from the clustered sample, specifically those who made an error and completed the non-routine mathematical problems in trigonometry during both the pre-test and post-test assessments. Purposive sampling involves a deliberate selection of samples based on specific criteria or requirements (Rohmah & Sutiarso, 2017). Hence, researchers select their samples based on specific considerations rather than relying on random selection; thus, they determine the sample composition.

Instrument

The researcher employed two sets of non-routine mathematical problems in trigonometry for the pretest and posttest assessments. These tests served as the primary data collection tools for the study, enabling the evaluation of students' problem-solving abilities in solving non-routine mathematical problems in trigonometry before and after integrating error analysis in teaching. The problems were taken from the modules and textbook developed by the Department of Education and other online published references. A guideline for scoring students' ability in problem-solving was adapted from Rohmah and Sutiarso (2017). It has a detailed guide on how to score the students' output in problem-solving and is aligned with Newman Error Analysis. Additionally, to interpret the learners' scores, a category level of ability in solving problems was adapted from Malikha and Amir (2018) as cited in Abadi & Amir (2022). The researcher checked and revised the entire guide to ensure its alignment with the study.

Lesson exemplars incorporating the error analysis strategy in activities were developed and implemented to teach non-routine trigonometry problems. Selected teachers and advisers checked the lesson plans before they were utilized as the research instrument. An error type adaptation indicator was adapted from Firdausi et al. (2023) from

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Alamsyam (2020) to determine the errors committed by the learners in solving non-routine problems in trigonometry. The researchers also employed semi-structured interviews based on the instrument outlined by Rohmah and Sutiarso (2017), which is aligned with Newman Error Analysis, to identify the underlying factors that contributed to the common errors committed by the students.

The researcher adviser and selected mathematics and English teachers were asked to check the content regarding the distribution of questions, grammar, alignment to the study, and accuracy of tests, guides, and interview questions before administration.

Data Collection

The data collection procedure started with the administration of a pretest consisting of a five-item test on non-routine mathematical problems in trigonometry. The tests were scored and interpreted according to adapted guidelines for scoring word problems, aligned with the principles of Newman Error Analysis. Subsequently, the student's responses were analyzed to identify the common errors they made when tackling non-routine mathematical problems in trigonometry, employing the framework of Newman Error Analysis.

It is followed by the implementation of the error analysis strategy using the crafted lesson exemplars with integration of the error analysis strategy. After the implementation of the strategy, a different set of five-item tests was given to the same set of students to determine their level of problem-solving abilities after the integration of the error analysis strategy. It was also scored and interpreted using the adapted guidelines used in scoring the pretest. Similarly, the same guidelines, Newman Error Analysis, were utilized to analyze the common errors committed by the learners.

Lastly, a semi-structured interview was conducted after the implementation of the posttest to identify the underlying factors that contributed to the common errors committed by the students based on the Newman Procedure after the integration of the error analysis strategy.

Treatment of Data

The data collected were tallied, tabulated, analyzed, and interpreted to be able to find the significant differences in the student's responses.

The Guidelines for Scoring Students' Ability in Problem-Solving Rohmah and Sutiarso (2017) were used to score the pretest and posttest of the respondents. Frequency and percentage were used to determine the level of problem-solving ability of Grade 9 students in solving non-routine mathematical problems in trigonometry before and after the integration of the error analysis strategy. A category level of ability in solving problems adapted from Malikha & Amir (2018) as cited in Abadi & Amir (2022) was utilized to interpret the descriptive results of the tests. Moreover, Pearson-r was utilized to determine the level of inter-rater reliability of the scores of the students' responses in problem-solving.

To compare the results of the pretest and posttest of the sample, a paired sample t-test was used. Frequency and mean were utilized to identify the common students' errors in solving non-routine mathematical problems in trigonometry based on Newman Error Analysis. The Error Type Adaptation Indicator adapted by Firdausi et al. (2023) from Alamsyam (2020), which categorized types of errors according to Newman, was used as a guide in analyzing the errors committed in the pretest and posttest.

Thematic analysis was utilized to analyze the responses of the participants in the semi-structured interview to determine the factors contributing to the students' errors.

Ethical Considerations

The researchers ensured that all research protocols involving ethics in research were complied with for the protection of all people and institutions involved in the conduct of the study.

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RESULTS and DISCUSSION

This presents the statistical data analysis and is subsequently interpreted and discussed. The presentation of the gathered data aligns with the focus established in the statement of the problem.

Level of the student's problem-solving abilities in solving non-routine problems in trigonometry before and after integrating error analysis

Table 1
Level of students' reading ability in solving non-routine problems in Trigonometry before and after integrating error analysis strategy

Percentage Scores	Before Integration f	Before Integration %	After Integration f	After Integration %	Ability Level
80%-100%	0	0%	12	41%	High
60%-79%	2	7%	15	52%	Moderate
0%-59%	27	93%	2	7%	Low
TOTAL	29	100%	29	100%	

Table 1 shows students' reading ability in solving non-routine problems in trigonometry before and after integrating the error analysis strategy. It was found that 41% of students developed high reading ability levels after integrating the strategy. This indicates that these students could accurately read and find at least 80% of the symbols, keywords, and mathematical symbols in the non-routine mathematical problems given to them. It was also determined that two students (7%) and 15 students (52%) could read and find 60% to 70% of the symbols, keywords, and mathematical concepts correctly from all the problems they answered before and after the integration of the error analysis strategy, respectively. Lastly, students with low reading ability are those students who read and identified less than 60% of the keywords, symbols, and mathematical symbols precisely in all the problems at the reading stage of problem-solving.

Table 2
Level of students' comprehension ability in solving non-routine problems in Trigonometry before and after integrating error analysis strategy

Percentage Scores	Before Integration f	Before Integration %	After Integration f	After Integration %	Ability Level
80%-100%	2	7%	23	80%	High
60%-79%	11	38%	5	17%	Moderate
0%-59%	16	55%	1	3%	Low
TOTAL	29	100%	29	100%	

Table 2 presents the comparison of the student's comprehension ability level in solving non-routine problems in trigonometry before and after integrating the error analysis strategy. Comprehension ability is the ability of the students to write what is known and asked in the problem, and it was found that before the integration of the strategy there are only 7% (2 students) could do at least 80% of it correctly while after the integration of the strategy, 80% (23 students) of the students would be able to do it. Moreover, there students with moderate comprehension ability levels who can also identify the correct given and what is the problem asking for but only between 60% to 79% of it are correct. Lastly, the 16 students (55%) before integration of the strategy which is lessened to 1 student (3%) after integration strategy could only identify less than 60% of the correct given and determine what is the problem asking for.

Table 3
Level of students' transformation ability in solving non-routine problems in Trigonometry before and after integrating error analysis strategy

Percentage Scores	Before Integration f	Before Integration %	After Integration f	After Integration %	Ability Level
80%-100%	0	0%	13	45%	High

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60%-79%	0	0%	9	31%	Moderate
0%-59%	29	100%	7	24%	Low
TOTAL	29	100%	29	100%	

The level of students' transformation ability in solving non-routine problems in trigonometry before and after integrating the error analysis strategy is shown in Table 3. When the student can accurately draw and create at least 80% of the figure that corresponds to the problem and the equation that can be used to solve the problem respectively, they are considered to have a high transformation ability level and 12 students (45%) could be able to do it after the integration of the error analysis strategy. On the other hand, students with moderate transformation ability levels could also do the same but were only able to score between 60% to 70% of the total score. Lastly, the low transformation ability level, 100% (29 students) of the students were on this level before the integration of the strategy. This level does not indicate that they cannot draw correct illustrations and create precise equations that correspond to the problem, they are classified with low transformation ability levels because they could be able to get only less than 60% of the correct answers at this stage of problem-solving.

Table 4
Level of students' process skill ability in solving non-routine problems in Trigonometry before and after integrating error analysis strategy

Percentage Scores	Before Integration		After Integration		Ability Level
	f	%	f	%	
80%-100%	0	0%	8	28%	High
60%-79%	0	0%	8	28%	Moderate
0%-59%	100	100%	13	44%	Low
TOTAL	29	100%	29	100%	

Shown in Table 4 are the levels of the students' process skills ability in solving non-routine problems in trigonometry before and after integrating the error analysis strategy. The process skills ability includes the ability of the students to perform and carry out the procedure to determine the answer correctly in problem-solving. When the students can do at least 80% of it correctly in all the problems given to them, they can be considered to have high process skills ability which was attained by 28% (8 students) students after the integration of the error analysis strategy. On the other hand, when the students could only be able to perform and carry out the solutions and obtained 60%-79% of the total score they are said to have moderate process skill ability like what 8 students (28%) demonstrated during the posttest. Finally, when the students could only get less than 60% of the total score in this stage, demonstrated by 29 students (100%) of the students before the integration of the error analysis strategy, they are said to have low process skill ability levels.

Table 5
Level of students' encoding ability in solving non-routine problems in Trigonometry before and after integrating error analysis strategy

Percentage Scores	Before Integration		After Integration		Ability Level
	f	%	f	%	
80%-100%	0	0%	6	21%	High
60%-79%	0	0%	3	10%	Moderate
0%-59%	29	100%	20	69%	Low
TOTAL	29	100%	29	100%	

Table 5 reveals the students' level of encoding ability in solving non-routine problems in trigonometry before and after integrating the error analysis strategy. Students are considered to have a high encoding ability level when they can render the correct conclusions of the problem. It does not mean that they should get it perfectly, but they must at least get not lower than 80% of it correctly, in all the problems given to them. 21% (6 students) of the students could be able to do it after the integration of the error analysis strategy. On the other hand, there 10% (3 students) who have moderate encoding ability level after the integration of the error analysis. They are those students who are unable to score at least 80% of the total score but still got higher than 59% of the total score. Lastly, 100% of the students during the pre-integration and 69% of the students during the post-integration of the error analysis strategy can write less than 60% of the conclusions of the problems correctly.

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Common errors in solving non-routine problems in trigonometry before and after integrating the error analysis strategy based on Newman's Procedure

The researchers also found common errors in solving non-routine problems in trigonometry before and after integrating the error analysis strategy based on Newman's Procedure.

The findings show that the students commit twelve different types of errors in different stages in solving non-routine problems in trigonometry based on the Newman Indicator before integrating the error analysis strategy. These errors occurred at various stages of problem-solving, with reading and transformation stages showing the highest frequency of mistakes, indicating these areas need particular attention.

The students committed errors mostly in the reading and transformation stages. They made errors in finding the mathematical concepts, symbols, and keywords and tended to just encircle random words, numerical values, or symbols in the problem, which all are considered reading errors. Similar to Firmansyah et al. (2021) and Riastuti et al (2017), they reveal that students' reading errors occur when they fail to identify keywords, symbols, and important information contained in each problem. Additionally, incorrect illustrations are the most common transformation errors since they could not identify the relationship between the figure and could not accurately put the label or measure on it. Similarly, Bayos (2020) also revealed that transformation error is the most common errors encountered by the students. An error which occurs when learners are unable to select a method or technique for creating illustrations or sketches that will aid in solving the problem (Hafid, Kartono, & Suhito 2016; Suyitno, 2018 as cited in Muttaqi et al., 2021).

The second common error students committed was in writing the formulas/equations to be used, solutions, and conclusions, categorized under transformation, process skills, and encoding errors respectively. On average, students committed these types of errors in 4 out of 5 non-routine problems in trigonometry that they answered before the integration of the error analysis strategy. Errors in writing the formula/equation happened due to a lack of knowledge of the topic and tended to utilize the fundamental operations, create their own formula, or apply topics from other lessons. Verzosa-Quinto and Mabansag (2023) state that transformation errors happen when there is a mistake in transforming information from a problem into a mathematical equation or solution, using incorrect formulas, or mixing incorrect procedures due to a lack of understanding of mathematical concepts, or confusion about the strategy to be used. On the other hand, errors in writing the solution occur due to an incorrect plan based on previous steps and incorrect execution and computation of the created equation. According to Swari et al. (2020), the student should already know the mathematical sentences and plan from the transformation stage because it will affect the process skill if they cannot understand and write the solution plan. Errors also occur in this stage when the students perform wrong calculations (Putri & Hastari, 2022). Lastly, the students encountered errors in writing the solutions due to incorrect calculations and answers from the previous steps as well as due to incorrect units or no units at all. Verzosa-Quinto and Mabansag (2023) also claim that encoding errors refer to inaccuracies in recording the results and applying the correct units. These errors also occur when the students are unable to get the right answer to the problem (Hafid, Kartono, & Suhito 2016; Suyitno, 2018 as cited in Muttaqi et al., 2021).

Furthermore, errors in reading mathematical concepts and symbols, which are classified as reading errors ranked third as the common errors that students encountered in solving non-routine problems in trigonometry wherein on average students committed errors in 3 out of the 5 problems they were given. The students encountered these errors because they could not read accurately or recognize symbols such as symbols for degrees or meters in the given problems. These errors are considered reading errors since according to Kusmayadi et al. (2022), these errors usually occur when students make mistakes in reading important words or cannot read or recognize the symbols used in the problem. Moreover, Firmansyah et al. (2021) claimed that reading errors happen because the students are not fluent in reading and lack the ability and knowledge about the symbols that appear in the given math problems.

It is followed by errors in writing down what is known and what is asked and incomplete writing of what is known in the problem which are all classified as comprehension errors based on Newman's Procedure. The students made errors on average of 2 problems from the 5 non-routine problems that they answered. As observed in the study, the students committed these types of errors when they failed to correctly identify the given information, often copying the entire problem or misinterpreting numerical values without proper descriptions. Similarly, errors in writing what was being asked happened when students wrote statements from the problem that didn't align with the actual question, copied the entire problem, or confused general instructions with the specific question. These are both consistent with Firmansyah et al. (2021) and Suyitno and Suyitno (2015) that comprehension error occurs when

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students cannot identify what is known and what is being asked in the problem or they identify the wrong information needed for this stage of problem-solving in the given problem.

Lastly, on average 1 out of 5 non-routine problems, the students were unable to write down and left the formula/equation to be used, the solution for solving the problem, and the conclusion blank, which is classified as a transformation error, process skills error, and encoding error based on Newman's Procedure. These last common errors all occur because the students left it blank or unanswered. It happens due to many factors such as they intentionally left it blank because they could not be able to find the answer and did not have enough time to accomplish it.

Generally, the students made errors in all the steps of solving non-routine problems in trigonometry before the integration of the error analysis strategy, and identifying these errors is beneficial to the students in different aspects. These errors are frequently encountered in every lesson and observed among students, particularly in the steps involved in problem-solving and the calculation process (Noutsara et al., 2021; Saleh et al., 2017; Muttaqi et al., 2021; Riastuti et al., 2017). Moreover, Van Lehn (1988) as cited in Tulis et al. (2016) said that errors are a common outcome of engaging in difficult learning activities and can, especially, offer chances for growth and understanding.

Error analysis strategy uses common errors in problem-solving to improve students' abilities, allowing them to identify, reflect on, and reduce their mistakes. It helps analyze errors at different stages, enabling precautions to avoid similar mistakes in the future. Findings show that the strategy lessened the common error committed by students from five to three ranking positions and decreased the twelve classified common error indicators to seven. After integrating the strategy, the highest average number of problems with specific errors dropped to three.

Error in writing the conclusions is the most common error after integrating the error analysis in solving non-routine problems in trigonometry. This is the final step in solving a problem, in this study, students commit errors in writing this step when they get an incorrect answer from the previous steps in problem-solving, put inaccurate units, or no units at all. According to Verzosa-Quinto and Mabansag (2023), encoding errors refer to inaccuracies in recording the results and applying the correct units. Also, Angco (2021) said that the student solved the problem but struggled to present the solution in an acceptable written format.

Encoding errors were followed by errors in drawing problem illustrations, errors in writing formulas/equations, and errors in writing solutions. The first two indicators are classified as transformation errors, while the last is categorized as process skills errors. Students made errors in drawing problem illustrations due to incomplete or misplaced labels and inaccurate drawings. Errors in writing formulas/equations occurred when students wrote equations that couldn't solve the problem or used mnemonics in trigonometry such as "TOA" instead of correct equations. According to Bayos (2020), most of the students grasped what the problem was asking them to find but could not be able to determine the correct operations or sequence of steps needed, preventing them from solving the problem and resulting in transformation error. Moreover, errors in writing the solutions occurred when the learner was able to provide an equation to solve the problem and managed to perform the specific procedure correctly but because the equation used to solve the problem is incorrect the result will be also considered wrong. It also happens when they accidentally input values that is different from the given or they cannot carry out the equation. Process errors happen when students identify the correct operation or sequence but lack the precision to execute them accurately, despite knowing the appropriate formula (Angco, 2021).

Lastly, errors in writing down what is known (comprehension error), incomplete writing of what is known (comprehension error), and errors in calculating (process skills error) were the third common errors observed in students' problem-solving attempts. Error in writing down what is known occurred when students identified numerical values but failed to describe what those values represented correctly. Incomplete writing of what is known happened when students could identify the numerical values but forgot to include the units or the accurate description of the values. Comprehension errors appear when the students write down what is known but not accurate and write it incompletely, making it unclear what it is about (Susanti & Taufik, 2019).

These errors have wide-reaching implications for students' comprehension and performance in mathematical problem-solving. Various factors contribute to these errors, as identified by participants in a semi-structured interview conducted to understand the underlying causes of students' mistakes in solving non-routine problems (Suyitno & Suyitno, 2015, as cited in Saleh et al., 2017).

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Factors contributing to the students' errors in solving non-routine mathematical problems in trigonometry

There are five themes emerged from the analysis of the interviews of the six participants from which can be seen in Table 6.

Table 6
Themes Generated from the Analysis of Interviews

Themes	Stages of Newman Analysis	Actual Responses	No. of Students
Lack of Understanding	Comprehension	I do not know the meaning of the words	2
		I do not understand	4
	Transformation	I do not understand	4
		I do not know where to put the labels	1
Misconception	Comprehension	I thought …	3
	Transformation	As what I have understand	1
		I thought it is always the same	2
	Process Skills	I thought …	2
Carelessness	Comprehension	I forgot to put/write	2
	Transformation	I did not notice	1
		I forgot to write/copy	2
	Process Skills	I did not check…	1
		I did not notice	2
		I think I pressed wrong button in calculator	1
	Encoding	I forgot the units	2
		I did not write the meters	1
Lack of Mastery	Transformation	I cannot make/create the formula	2
		I got confused when I am only one answering	1
	Process Skills	I forgot the process/what to do	3
		I got confused	1
		I do not know what to press	1
Compounding Error	Process Skills	My equation is wrong, so my solution is also wrong.	1
		Because my answer here (previous step) is wrong	3
	Encoding	The solution is wrong therefore the conclusion is also incorrect	2
		If you make a mistake in one step all steps will be wrong	1
		Because the previous step is wrong	2

A. Lack of Understanding

It is important for the student to understand the problem before solving it because when the students can understand the words stated on it, they can solve it (Simbulas et al., 2015). However, in the interview, it was revealed that the students are lacking the ability to understand the problems and the words and terminologies used. It was found that it is the topmost reason why the students were committing errors in the comprehension stage of problem-solving. This stage mainly focuses on the given and what the problem is asking. During the interview Student 1 (S1) said …

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"I am confused with the problem. I know that the given pertains to the numbers, but I am not sure what the numbers imply… I do not know the meaning of some words in the problem, so I only put the words that I know in the given."

Similarly, Student 6(S6) also said…

"I make mistakes sometimes in writing the given because I do not understand some English words. I thought that it pertains to this number, but it comes out that it is talking about the other one."

The participants clearly said that they knew that givens are about numerical values however they could not describe it because they did not understand the problem itself, the words, and the language used therefore, they provided the wrong description of the given or just included the numerical values without its description. On the other hand, it was also noticeable that they managed to get some of the correct given in the problems and what is the problem asking for, so the participants were asked how they managed to identify it correctly. Student 4 (S4) and Student 5(S5) told that …

"Honestly, I don't understand the problem. I just read it, get the numbers, and then I'll pick those words near to the numbers that I picked so I can have this (description)"

"I just put those words close to the numbers to have the complete given and then for What is the problem asking for, I am picking the last sentence."

With this, it was clarified that they managed to get the correct answer in the comprehension stage not because they understood the problem but because they developed their technique on how to get some of the correct answers for the comprehension stage.

Moreover, this interview also revealed that the comprehension stage is not the only stage affected by students' lack of understanding but also the transformation stage. This stage concentrated on transforming the problem into its corresponding mathematical model, the illustration, and the equation to be used to solve the problem. S1 and S4 stated that they committed an error in the transformation stage, specifically in drawing the illustration of the problem because …

"I am really confused where to put the values in the problem, whether it is on the side or on the angle. I cannot put the labels, similar to the given, because I do not understand the problem."

"I only put in the illustrations those figures that is familiar to me in the problem, like the kite, but I cannot put the measurements because I do not understand the problem since it is written in English".

It was discovered that the incorrect illustrations were due to a lack of understanding of the problem. The students only drew images that they understood and were familiar to them but not in appropriate positions and the labels were misplaced because they did not know where to put them due to a lack of understanding of the problem.

This means that a lack of understanding of the problem is one of the factors contributing to the errors that the students went through in answering non-routine problems in trigonometry. As cited by Patac and Patac (2015), in the study conducted by Raduan (2010) they found that lack of understanding is the topmost reason why students make errors in mathematical word problems. Miranda (2004) as cited in Bayos (2020) also determined that students made comprehension errors because they struggled to quickly and accurately understand the keywords and terms in the problem, leading to their inability to effectively analyze it.

B. Misconceptions

According to Luneta and Makonye (2010) as cited in Arnawa et al., 2019 errors and misconceptions are different, but they are related. Misconceptions happen due to misunderstanding and when a student thinks that a wrong concept is true while errors are inaccuracies that can be caused by misconceptions. The students thought that what they were doing was correct, which is why misconceptions happened and during the interview with the participants it was discovered that some comprehension, transformation, and process skills errors in problem-solving were due to their misconceptions. S1 and student S4 said that they intentionally did not consider some of the given because…

"I thought I only have to put two givens because we only have two on our example before."

"I thought we always have two givens, and the third one is always unknown."

Aside from they had lack of understanding of the problem, they also had the misconception that problem-solving is similar to the previous topics about triangles and had the conclusion that there should be only two given in solving triangles adding to the factors of their errors in the comprehension stage. Additionally, units are important in mathematics, and omitting it will result in an error and this is another misconception as said by Student 5…

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"I did not write the meter, I thought it was okay not to include that, that the number is enough, but I did not find it hard to find the given."

Furthermore, misconception is also a factor in the students' errors in problem-solving, specifically in writing the equation to be used to solve the problem in the transformation stage, as the interview revealed. Student 2 and S6, said that the errors were due to …

"As I have understood before, we also did this in another topic in solving triangles, I only have to identify the trigonometric ratio that I am going to use therefore I only put TOA. I did not write my equation here, I put it in the solutions."

"I memorized the equations in our examples during our discussion, then I put it here. I thought it was always the same."

It can be said that the errors in transformation abilities are because of their false thinking that the equation/formula to be used is the mnemonics of the six trigonometric ratios and the solutions and numerical figures should be put in the solutions only. They also think that the equation/solution is not changing similar to the formula of different geometrical figures.

Another stage of problem-solving that was concerned with students' misconceptions as a factor of their errors was the process skills stage. They committed errors because they are always sticked to the previous examples and memorized the solutions and procedures because they thought that it was always the same. As S3 and S6 stated, errors were because …

"I thought it is similar with your examples in the discussion, so I just copied it."

"I thought that it is addition because the example in our lesson is in addition, so I thought there is no subtraction here always addition."

From the above claims and statements of the participants, it can be concluded that misconceptions contributed to students' comprehension errors, process skills errors and transformation errors.

C. Carelessness

In mathematics, being careful is very important because being unable to notice accidental changes, even if it is minimal, will result in a larger mistake but carelessness happens most of the time in problem-solving. According to Rohmah & Sutiarso (2017), students are not careful in the process of problem-solving. Students tend to rush to work with the problem without checking and examining the results of the problem that they are solving. Carelessness was evident in the four problem-solving stages mostly in the process skill stage. They accidentally changed values, forgot to write the units, encoded different values in the calculator, forgot to put the labels, and made mistakes in copying from their scratch paper. Student 2 and S3 said …

"I forgot to write the angle of elevation, but I understand it. I did not find it hard."

"Because I always use scratch paper first when answering so I always run out of time. I rushed in writing my answers in the test paper, so I forgot to put the description of the given, I wrote first the solutions because that is more important."

It was found that incomplete answers in the identification of given were due to carelessness. They forgot to include some important words such as elevation in angle of elevation and they forgot to copy it from their scratch papers resulting in comprehension errors. On the other hand, in the transformation stage, the students committed errors because they were unable to copy the correct illustrations from the scratch paper and others thought they had already written them. S3 and S6 said …

"I wrote my illustration first in a scratch paper then I transferred it to the test paper. I did not notice that I forgot to copy some values."

"After I created a triangle, I forgot to write the numbers. I thought I already wrote but it is just in my mind."

Furthermore, carelessness is also a factor in errors mostly in process skills. It is the stage where the students perform the process of the solution of problem-solving and is very prone to errors due to the numerical values and symbols. When their answers were given to them again and asked to observe and tried to use to calculator to check S2, S3 and S5 said …

"I did not write the 0, 30 becomes 3, that is why at the end I got confused. I did not check it above that is why it is wrong."

"45 degrees is wrong, it should be 42 but I wrote 45. I am running out of time I did not notice that."

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"Oh! The value here in the calculator is different now from my answer in the test. I think I pressed the wrong number during exams."

Lastly, encoding errors happened also due to students' carelessness. Forgetting to write the units is the major source of errors in this stage. Like what S2 said when asked why the solution was correct, but conclusions were not in his work …

"Oh no! I forgot the unit. I did not write the meters. I forgot to write it."

It was evident that after they saw their work again during the interview they discovered and knew what their errors were and told that it was mostly because they forgot to include, copy, or write, encode in the calculator, mistake in copying values due to their carelessness. This implies that carelessness is also a factor that contributes to the errors committed by the students in problem-solving. In line with this, Angco (2021) also claimed that errors arise from students' carelessness, as they are not meticulous with calculations, fail to review their answers before submission, and do not carefully read the provided information.

D. Lack of Mastery

Mastery of different mathematical concepts and procedures is essential in accomplishing the steps in problem-solving; lack of it will have a big impact on solving problems. We can say that a mathematics concept or skill has been mastered when an individual can apply it to a new problem in an unfamiliar situation (Drury 2014 as cited in Askew et al., 2015) and it was revealed in the interview that the students lacked mastery on different mathematics skills or topic needed to solve the problem. It was found that a lack of mastery of the topic contributed to the errors encountered in the transformation stage and process skills stage. S2 and S4 said …

"I forgot which one is the adjacent so I cannot make the formula."

"I got confused about what formula to write. I understood it during the discussion, but I got confused when I was the only one answering and the problem was different, so I just guessed the equation and came up with the wrong solutions."

It was evident that the reason that they could not write the equation/formula to be used was due to a lack of mastery of the topic as they forgot the concept of adjacent which is very important in creating the equation for the problem. Also, the students could not apply what they have learned during the discussion to a new situation or new problem and resort to guessing the equation resulting in a transformation error.

S3: I forgot the process so I cannot continue the solutions. I forgot what to do.

S6: I got confused about how to cross-multiply and divide the ratios.

S1: I do not know what to press in the calculator, so I get the wrong answer.

The excerpt from answers of S3, S6, and S1 show that lack of mastery also caused errors in process skills. It shows that they could not solve the problem because they forgot how to perform specific procedures indicating that they lacked mastery of the topic and mathematical skills needed to solve the problem. Errors occur when the students forget the process due to their weakness in mastering the topics (Patac & Patac, 2015). It was also affirmed by Wahab et al. (2014) as cited in Thomas and Mahmud (2021) that a lack of mastery of mathematical topics can significantly contribute to errors, as students may not have the necessary knowledge to solve problems accurately.

E. Compounding Errors

According to White, in order to solve a mathematical problem, a person must be able to overcome a series of related challenges, including reading, comprehension, transformation, process skills, and encoding (Zamzam & Patricia, 2018). Since problem-solving is composed of an interrelated series of steps mistakes made in the initial steps have a higher probability of causing mistakes in subsequent steps and producing an inaccurate result (Zulyanty & Mardia, 2022). In this study, interviews also revealed that process skill errors and encoding errors were due to compounded errors from the previous steps of problem-solving. S5 said…

"I can solve ma'am, I know how to perform and carry out the solutions, but I cannot understand the problem. I cannot make the correct equation which is why I cannot get the correct answers."

This shows that even if the students know how to carry out a plan and algebraic manipulations, in problem-solving if they do not identify the previous steps correctly such as identifying the given and creating the equation they will still get the wrong answer. In this case process skills errors were due to the errors in comprehension and transformation stage of problem-solving. Similarly, S6 said …

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"To make the conclusions, I will get my answer in what is the problem asking for then connect the answer I get from the solution, but the answer I get from my solution is wrong therefore my conclusion is also incorrect."

It was the response when the student was asked how he created his conclusions and why he thought it was wrong. The student knew how to properly conclude, in complete sentences and with proper units, however, as he mentioned, the error was committed at the initial steps, therefore, there will be errors until the last steps, an instance where process skills errors affect encoding errors. Another response shows compounding errors from S3, where errors in the initial steps affect the following steps.

"It is hard for me to draw the illustration and create the formula therefore I also find it hard to carry out the solution, it is also wrong. It is hard. If you make a mistake in one step all steps will also be wrong."

Another claim supporting these findings is from Ahzan et al. (2022), stating that in problem-solving previous phase can affect the following phase since they found that an error in the transforming stage will result in process skills error and encoding error. Similarly, Angco (2021) also claimed that incorrect conclusions were due to the errors committed in the previous steps of problem solving.

Lastly, the researchers determined whether there is a significant difference between the scores of students' problem-solving ability in solving non-routine problem in trigonometry before and after integration of the error analysis strategy.

Table 7
Test of Difference in Problem-solving Ability of the Students Before and After the Integration of Error Analysis Strategy

	Pretest		Posttest		t	df	Sig.(2-tailed)
	M	SD	M	SD			
Reading Ability	4.62	2.74	11.10	1.78	-12.309	28	0.000
Comprehension Ability	7.97	2.99	12.90	2.14	-8.399	28	0.000
Transformation Ability	4.86	0.52	10.72	2.88	-10.933	28	0.000
Process Skills Ability	4.00	1.69	9.76	3.14	-8.232	28	0.000
Encoding Ability	3.69	2.07	7.72	3.43	-5.438	28	0.000

Table 7 shows the test of the difference between the students' problem-solving ability in solving non-routine problems in trigonometry before and after the integration of the error analysis strategy. It was shown that there was an increase in all mean scores between the pre-test and post-test of reading ability, comprehension ability, transformation ability, process skills ability, and encoding ability, all in favor of the post-test. It was found that these difference between the mean of the pretest and post-test of the reading ability (t=-12.309, p=0.000), comprehension ability (t=-8.3999, p=0.000), transformation ability (t=-10.933, p=0.000), process skills ability (t=-8.232, p=0.000) and encoding ability (t=-5.438, p=0.000) are all significant at 0.05 level of significance.

These findings imply that integrating the error analysis strategy helps in developing the students' problems solving ability namely the reading ability, comprehension ability, transformation ability, process skills ability, and encoding ability, in solving non-routine problems in trigonometry. It also indicates that the error analysis strategy helps to analyze, identify, and lessen the errors committed by the students in solving non-routine problems in trigonometry. Moreover, it also shows the importance and benefits of identifying errors and utilizing them in the teaching and learning process of problem-solving. The investigation and remediation of common math errors were effective in enhancing learning goals and fostering positive behavioral changes (Patac & Patac, 2015) and can help teachers understand their students' mathematical difficulties, thereby benefiting the learning process (Dacsa, 2022). Similarly, Khasawneh et al. (2022) also claims that error analysis-based learning resulted in a considerable improvement in and contributed to giving students with good experiences in mathematics learning. It encourages students to build multiple answers and analyze the rationale of others, implying that examining correct and incorrect solutions leads to higher performance than dealing just with correct solutions.

Conclusions

It was concluded that the error analysis strategy helps in the development of the problem-solving ability of the students. It was also determined that the most common errors committed by the students before integrating the error analysis strategy were reading errors and transformation errors specifically in finding the mathematical concepts, symbols, and keywords and drawing the illustration of the problem. However, after integrating the error analysis strategy it was found that encoding errors are the most common errors committed by the students in solving

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non-routine problems in trigonometry. Additionally, the researchers also found that the factors contributing to the errors of the students in solving non-routine problems in trigonometry are lack of understanding, misconception, carelessness, lack of mastery, and compounding errors. Furthermore, difference between the students' problem abilities before and after the integration of the error analysis strategy in solving non-routine problems in trigonometry are significant.

Recommendations

Students are advised to utilize an error analysis strategy in learning problem-solving and mathematics. It is also suggested that teachers may integrate error analysis strategy not just in solving non-routine problems but also in other problem-solving and topics in Mathematics and should also pay attention to encoding ability since it was found that encoding errors were the most common error committed by the students. Lastly, future researchers may do parallel studies using other locales, an increased number of respondents, and long-term research to further analyze the benefits of integrating error analysis in developing students' problem-solving abilities and other factors that may contribute to the errors that the students committed.

REFERENCES

Abadi, M. A. S., & Amir, M. F. (2022). *Analysis of the Elementary School Students Difficulties of in Solving Perimeter and Area Problems*. JIPM (Jurnal Ilmiah Pendidikan Matematika), 10(2), 396. https://doi.org/10.25273/jipm.v10i2.11053

Abenojar, M. B. (2024). Effectiveness of Directed Reading Thinking Activity (DRTA) in Improving the Reading Comprehension of Grade Three Pupils. International Journal of Open-access, Interdisciplinary and New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR), 3(2), 435-446. https://etcor.org/storage/iJOINED/Vol.%20III(2),%20435-446.pdf

Ahzan, Z. N., Simarmata, J. E., & Mone, F. (2022). *Using Newman Error Analysis to detect students' error in solving junior high school mathematics problem*. Jurnal Pendidikan MIPA, 23(2), 459–473. https://doi.org/10.23960/jpmipa/v23i2.pp459-473

Alcantara, E. C., & Bacsa, J. M. P. (2017). *Critical thinking and problem solving skills in mathematics of Grade-7 public secondary students*. Asia Pacific Journal of Multidisciplinary Research, 5(2), 21–25. https://doaj.org/article/d58a7fe9c8994e6a9a3164be3cffdfa0

Aminudin, M., Nusantara, T., Parta, I. N., Rahardjo, S., As'ari, A. R., & Subanji, S. (2019). Engaging problems on trigonometry: why were student hard to think critically? Journal of Physics: Conference Series, 1188(1), 012038. https://doi.org/10.1088/1742-6596/1188/1/012038

Angco, R. J. (2021). Error Analysis in Integral Calculus: A Modified Newman's Approach. American Research Journal of Humanities Social Science (pp. 38–52). https://www.arjhss.com/wp-content/uploads/2021/09/F493852.pdf

Anggraini, R., & Putra, E. S. (2020). The Ability of cadets to solve trigonometry routine and non-routine problems. Journal of Physics: Conference Series, 1480(1), 012027. https://doi.org/10.1088/1742-6596/1480/1/012027

Arnawa, I. M., Yerizon, & Nita, S. (2019). *Errors And Misconceptions In Learning Elementary Linear Algebra.* Journal of Physics: Conference Series, 1321, 022095. https://doi.org/10.1088/1742-6596/1321/2/022095

Askew, M., Bishop, S., Christie, C., Eaton, S., Griffi, P., & Morgan, D. (2015). *Year 3 Teaching for Mastery for Teaching of Mathematics* Excellence in the MathsHUBS Maths. https://impetus-education.co.uk/wp-content/uploads/2015/12/Mastery_Assessment_Y3_Low_Res.pdf

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E - ISSN 1908-3181

Badriani, I., Wyrasti, A. F., & Tanujaya, B. (2022). *Student errors in solving HOTS based-match story problems with Newman's theory*. Jurnal Elemen, 8(1), 77–88. https://doi.org/10.29408/jel.v8i1.4199

Bayos, L. B. (2020). Analysis of Errors in Solving Mathematical Problems Involving Fractions. Research Publish Journals. https://www.researchpublish.com/upload/book/ANALYSIS%20OF%20ERRORS%20IN%20SOLVING-8116

Chusnul, C. R., Mardiyana, & Retno, S. (2017). *Errors analysis of problem solving using the Newman stage after applying cooperative learning of TTW type*. AIP Conference Proceedings. https://doi.org/10.1063/1.5016662

Creighton, S. J., Tobey, C. R., Karnowski, E., & Fagan, E. R. (2015). *Bringing math students into the formative Assessment equation: Tools and Strategies for the middle grades.* https://doi.org/10.4135/9781483385945

Dacsa, J. (2022). SOLO Taxonomy and Newman Error Analysis: Understanding the Difficulties of Students in Solving Word Problems in Pre-Calculus. Philippine EJournals, 10(2), 97–102.

Ersoy, E. (2016). *PROBLEM SOLVING AND ITS TEACHING IN MATHEMATICS.* The Online Journal of New Horizons in Education. https://tojqih.net/journals/tojned/articles/v06i02/v06i02-11.pdf

Firdausi, F., Rohmatin, D. N., & Rahmawati, A. (2023). *Analysis of student errors in solving math word problems on matrix material: A Self-Confidence View Point*. International Journal of Research Publication and Reviews, 4(2), 1705–1711. https://doi.org/10.55248/gengpi.2023.31451

Firmansyah, M. A., Nopitasari, D., Syarifah, L. L., & Yulianah, R. (2021). *Error Procedure Analysis Based On Newman In Solving Logarith M Questions Review Student's Beginning Mathematics Ability.* Prima: Jurnal Pendidikan Matematika, 5(2), 16. https://doi.org/10.31000/prima.v5i2.4491

Fortes, E. C., & Andrade, R. R. (2019). *Mathematical creativity in solving Non-Routine problems.* The Normal Lights, 13(1). https://doi.org/10.56278/tnl.v13i1.1237

George, T. (2023, June 22). *Mixed Methods Research | Definition, Guide & Examples*. Scribbr. https://www.scribbr.com/methodology/mixed-methods-research/

Hortal, K. A. (2021). Mathematical Podcast (Mathpod): A Learning Tool In Improving Students' Problem-Solving Skills In Mathematics 10. Deped | Division Of Biñan. https://www.depedbinan.com/media/research/IMRD_Hortal_Kristela_Janine_A.___MNHS

Khasawneh, A. A., Al-Barakat, A. A., & Almahmoud, S. A. (2022). *The Effect of Error Analysis-Based Learning on Proportional Reasoning Ability of Seventh-Grade students.* Frontiers in Education, 7. https://doi.org/10.3389/feduc.2022.899288

Kusmayadi, T. A., Sahara, S., & Fitriana, L. (2022). *Application of Newman Errors Analysis theory related to mathematical literacy problems: A case study of secondary students in class 11.* AIP Conference Proceedings. https://doi.org/10.1063/5.0117183

Legarde, M. A. (2022). Students' Common Errors in Solving Routine & Non-Routine Problems: A Mixed Method Analysis. International Journal of Multidisciplinary Research and Analysis, 05(05). https://doi.org/10.47191/ijmra/v5-i2-42

Muttaqi, U. K., Kartono, K., & Dwidayanti, N. K. (2021). *Diagnostic Analysis of Newman's Types of Students' Error in Finishing Questions of Mathematical Problem Solving.* Unnes Journal of Mathematics Education Research, 10(A), 32–40. https://journal.unnes.ac.id/sju/index.php/ujmer/article/view/34302

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Noutsara, S., Neunjhem, T., & Chemrutsame, W. (2021). *Mistakes in mathematics Problems solving based on Newman's error analysis on set materials.* Journal La Edusci, 2(1), 20–27. https://doi.org/10.37899/journallaedusci.v2i1.367

Patac, L. P., & Patac Jr., A. V. (2015). *An Application of Student Self- Assessment and Newman Error Analysis in solving Math Problems*. Recoletos Multidisciplinary Research Journal, 3(1), 207–213. https://doi.org/10.32871/rmrj1503.01.17

Putri, R. I. S., & Hastari, R. C. (2022). *Analysis of student errors in solving HOTS-Type sequence and series problems based on Newman Error analysis*. AlphaMath: Journal Mathematics Education, 8(2), 143. https://doi.org/10.30595/alphamath.v8i2.14837

Rayan. (2019, April 1). *The importance of mathematics in the modern world.* The Superprof Blog - UK. https://www.superprof.co.uk/blog/maths-and-the-modern-world/

Riastuti, N., Mardiyana, M., & Pramudya, I. (2017). *Students' Errors in Geometry Viewed from Spatial Intelligence.* Journal of Physics: Conference Series, 895, 012029. https://doi.org/10.1088/1742-6596/895/1/012029

Rohmah, M., & Sutiarso, S. (2017). *Analysis Problem Solving in Mathematical Using Theory Newman*; Eurasia Journal of Mathematics, Science and Technology Education, 14(2). https://doi.org/10.12973/ejmste/80630

Rushton, S. J. (2018). *Teaching and learning mathematics through error analysis.* Fields Mathematics Education Journal, 3(1). https://doi.org/10.1186/s40928-018-0009-y

Saleh, K., Yuwono, I., As'ari, A. R., & Sa'dijah, C. (2017). *Errors analysis solving problems analogies by Newman procedure using analogical reasoning.* International Journal of Humanities and Social Sciences, 9(1). https://ijhss.net/index.php/ijhss/article/download/253/89

Simbulas, J. C., Regidor, B. T., & Robelyn Catulpos. (2015). *Reading Comprehension and Mathematical Problem Solving Skills of University of the Immaculate Conception Freshmen Students*. 21(2), 1–1.

Sumule, U., Amin, S. M., & Fuad, Y. (2018). *Error analysis of Indonesian Junior High school student in solving space and shape content PISA problem using Newman procedure.* Journal of Physics: Conference Series, 947, 012053. https://doi.org/10.1088/1742-6596/947/1/012053

Susanti, R. D., & Taufik, M. (2019). *Analysis Student Mistake of Teacher Professional Education In Completing Story Problems Based on Newman Procedures.* International Journal of Trends in Mathematics Education Research, 2(2), 72. https://doi.org/10.33122/ijtmer.v2i2.59

Suyitno, A., & Suyitno, H. (2015). *Learning therapy for students in mathematics communication correctly based-on application of newman procedure (a case of indonesian student).* International Journal of Education and Research, 3(1). https://ijern.com/journal/2015/January-2015/44.pdf

Swari, C. D. V. S., Mardiyana, & Indriati, D. (2020). *Analysis of mathematical problem solving based on stages Newman in equality and inequality one variable.* Journal of Physics: Conference Series, 1511(1), 012094. https://doi.org/10.1088/1742-6596/1511/1/012094

Tanu Wijaya, T., Ying, Z., & Purnama, A. (2020). Using Hawgent Dynamic Mathematic Software in Teaching Trigonometry. International Journal of Emerging Technologies in Learning (iJET), 15(10), pp. 215–222. https://doi.org/10.3991/ijet.v15i10.13099

Thomas, D. S., & Mahmud, M. S. (2021). *Analysis of students' error in solving quadratic equations using Newman's procedure.* International Journal of Academic Research in Business & Social Sciences, 11(12). https://doi.org/10.6007/ijarbss/v11-i12/11760

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Thomas, L. (2023, June 22). Cluster Sampling | *A Simple Step-by-Step Guide with Examples.* Scribbr. https://www.scribbr.com/methodology/cluster-sampling/#:~:text=What%20is%20cluster%20sampling%3F

Timario, R. R. (2020). *Reading Comprehension and Problem Solving Skills Of Grade Seven Students: A Mixed Sequential Explanatory Approach.* American Journal of Humanities and Social Sciences Research (AJHSSR). https://www.ajhssr.com/wp-content/uploads/2020/06/K20468391

Tulis, M., Steuer, G., & Dresel, M. (2016). *Learning from errors: A model of individual processes.* Frontline Learning Research, 4(4), 12–26. https://doi.org/10.14786/flr.v4i2.168

Verzosa-Quinto, E. M., & Mabansag, A. B. (2023). *Error Analysis in Solving Word Problems among Grade-8 Students.* International Journal of Current Science Research and Review, 06(10). https://doi.org/10.47191/ijcsrr/v6-i10-10

Zamzam, K. F., & Patricia, F. A. (2018, January 1). *Error Analysis of Newman to Solve the Geometry Problem in Terms of Cognitive Style.* Www.atlantis-Press.com; Atlantis Press. https://doi.org/10.2991/incomed-17.2018.5

Zulyanty, M., & Mardia, A. (2022). *Do students' errors still occur in mathematical word problem-solving?: A newman error analysis.* Al-Jabar: Jurnal Pendidikan Matematika, 13(2), 343–353. https://doi.org/10.24042/ajpm.v13i2.13519