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Error Analysis in Solving Word Problems among Grade-8 Students

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ABSTRACT: Despite the importance of problem-solving skills in preparing students for the workforce and the emphasis on problem-solving in mathematics education, studies have shown that many students struggle with mathematics problem-solving. In the Philippines, low proficiency in mathematics and a high prevalence of errors in problem-solving have been observed, emphasizing the need for further improvement in students' problem-solving abilities. This research investigated the errors made by eighth-grade students of Talalora National High School in solving word problems and examined their impact on reading comprehension and analytical skills. A quantitative correlational design was employed, and standardized tests were used as data-gathering instruments. The analysis involved statistical measures such as frequency counts, percentages, mean, and standard deviation, as well as inferential statistical methods, including chi-squared for dependence, to establish correlations. The results showed that most respondents were 13 years old, with the instructional level of comprehension being the dominant category. The chi-squared test indicated a significant relationship between reading comprehension levels and problem-solving errors $X^2(6, N = 20) = 26.726$, $p < 0.001$, Cramer's $V = 0.817$. The identified errors were primarily related to challenges in comprehending and evaluating the problems. The study emphasized the importance of reading comprehension and analytical skills in solving word problems and suggested that educators should focus on developing these abilities to enhance students' problem-solving proficiency.

KEYWORDS: Analytical ability, Error analysis, Grade-8 students reading comprehension, problem-solving.

INTRODUCTION

Problem-solving skills are essential in learning and have become increasingly important today. These skills are critical in preparing students for the workforce, as they are expected to identify and solve problems that arise in various settings. Problem-solving is crucial in science, technology, engineering, and mathematics (STEM) fields. According to the National Council of Teachers of Mathematics (NCTM), problem-solving is one of the primary goals of mathematics education. Students must learn to apply mathematical concepts to real-world situations (Capraro & Nite, 2014).

However, despite the importance of problem-solving skills, studies have shown that many students need help solving mathematics problems (Krawec, 2014; Granberg, 2016). Errors in problem-solving are not limited to specific concepts but rather occur in a wide range of mathematical topics (Schoenfeld, 2016). Yadav and colleagues (2014) showed that errors in problem-solving are common among elementary and high school students. In Turkey, Incebacak and Ersoy (2016) conducted research in secondary schools, indicating that students struggle to solve mathematical problems. Tambunan (2019) found that Indonesian students also faced difficulties when solving mathematical problems, while Raoano's (2016) study in South Africa attributed students' deficiencies in problem-solving abilities to language barriers. Santos et al. (2015) also found that nearly half of the respondents in a study exhibited unsatisfactory performance in translating worded problems due to carelessness, insufficient comprehension, interchanging values, and unfamiliarity with certain words.

In the Philippines, the Trends in International Mathematics and Science Study (TIMSS 2019) revealed that only 19 percent of eighth-grade students demonstrated proficiency in mathematics, indicating a need for improvement in problem-solving skills. This emphasizes the need for developing students' problem-solving abilities further. The 2019 National Achievement Test (NAT) results showed that the average percentage score of grade 6 students in mathematics was only 50.73 percent, which is lower than the target mean percentage score of 75 percent set by the Department of Education. These results showed that Grade-6 students in the Philippines still struggle with mathematics, particularly problem-solving.

Despite the prevalence of errors in problem-solving and the need to improve student's performance in mathematics, few studies have focused on analyzing the errors made by students in solving problems in mathematics. The data mentioned above

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emphasize the necessity to conduct a more in-depth examination of students' problem-solving abilities in mathematics and scrutinize the kinds of errors made by students. This can aid teachers in formulating appropriate instructional methods to tackle these errors in problem-solving. To address the research gap, this study conducted an error analysis of Grade-8 students' problem-solving skills in mathematics. The study utilized Newman's Error Analysis framework to identify various errors, including comprehension, transformation, process skills, and encoding errors. The results of this study would be utilized to develop targeted interventions to improve students' problem-solving skills. By addressing the mistakes made by students, researchers can design improved instructional methods, enhancing the overall quality of mathematical education.

This study investigated students' problem-solving errors as contributed by their reading comprehension and analytical abilities.

Specifically, this study had answered the following questions:

1. What is the profile of the participants in terms of the following:
   - 1.1 age and sex;
   - 1.2 reading comprehension ability, and
   - 1.3 analytical ability?
2. What are the errors exhibited by the participants along:
   - 2.1 reading comprehension, and
   - 2.2 analytical ability?
3. Is there a significant relationship between the profile of the participants and errors exhibited by the participants?

Significance of the Study

The research holds significant implications for various stakeholders in the education system, such as school administrators, curriculum planners, teachers, and parents.

School administrators. The study's results would provide valuable insights into the quality of mathematics instruction given to eighth-grade learners and the efficiency of the school's mathematics instruction. The study's outcomes would provide direction for decisions regarding enhancements to the curriculum and professional development opportunities for teachers, which may contribute to an improvement in the school's overall performance.

Curriculum planners. The study would provide helpful ideas to curriculum planners regarding the areas where learners in 8th grade face difficulties when solving word problems. Hence, they may benefit from it. The study could present the development of more effective instructional materials and strategies to address these areas of difficulty.

Teachers. Teachers could use the study results to enhance their pedagogical approaches and provide more effective support for their learners' educational needs. The research findings could contribute to developing focused interventions to assist students with difficulties in some areas of word problem-solving, such as assessing relevant data or determining an appropriate mathematical operation.

Parents. The study's results would give parents a broader understanding of their child's mathematical learning necessities. The outcomes would facilitate discussions with the teachers and improved their ability to assist with their children's mathematical education within the household.

Definition of Terms

For this study, the following terms were used conceptually and operationally:

Analytical Ability. Conceptually, it deconstructs information into smaller categories to conclude. This ability helps individuals in solving word problems. Understanding the parts of the situation and scrutinizing and breaking down facts is essential (Danesh & Nourdad, 2017). Operationally, analytical ability is the cognitive aptitude to analyze and evaluate mathematical concepts and procedures objectively. The concrete application of this concept will be achieved by utilizing the Test of Logical Analysis, which assesses academic aptitude. This assessment will gauge students' cognitive abilities, encompassing their capacity to analyze and resolve mathematical problems.

Comprehension Error. Conceptually, this is the error exhibited by the students when he/she can read all the words in the question but need help understanding the meaning, making it impossible for them to proceed to solve the given word problem (Agustiani, 2017). Operationally, comprehension error pertains to an error that occurs during the second stage. This stage involves

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the comprehension of the textual material of the problem. Examining the cognitive processes employed by students during problem-solving activities and the specific types of errors they commit at each stage allowed the identification of comprehension errors. This was accomplish using a framework based on Newman's Error Analysis.

Encoding Error. Conceptually, this is the error exhibited by the students when he/she can solve a problem correctly but need help to express it in a correct and proper written form (Agustiani, 2017). Operationally, refers to inaccuracies in the recording or expressing a problem's solution. Mistakes can occur during various stages of numerical computations, such as when transferring values from one operation to another, when recording the result, or when applying appropriate units of measurement or notation.

Error Analysis. Conceptually, refers to a methodical and organized approach of recognizing, classifying, and examining the various kinds and origins of mistakes learners commit while resolving mathematical word problems. The analysis aims to discern patterns and trends in the categories of student errors, along with the fundamental cognitive processes and strategies employed while tackling problems (Agustiani, 2017). Operationally, error analysis will be conducted in the study by examining the problem-solving processes and responses of grade 8 students when solving standardized mathematical word problems. The errors will be categorized based on the stages of Abdullah's five-stage model of mathematical problem-solving and other relevant factors such as the type of error and the frequency of occurrence.

Problem-Solving. Conceptually, it is a mathematical task that has the potential to provide intellectual challenges for enhancing students' mathematical understanding and development (Danesh & Nourdad, 2017). Operationally, problem-solving refers to the cognitive process of using logical reasoning and mathematical skills to solve mathematical word problems. Its process requires students to use various cognitive strategies, such as identifying relevant information, making inferences, applying mathematical concepts and procedures, and checking their work for accuracy. In the study, problem-solving was assess by analyzing the problem-solving processes and responses of grade 8 students when solving a set of standardized mathematical word problems. The analysis focused on the types and sources of errors students make during the problem-solving process and their underlying cognitive processes and strategies.

Process Skills Error. Conceptually, this is the error exhibited by the students when he/she can recognize proper operations but need to learn how to carry out these operations correctly (Agustiani, 2017). Operationally, process skills errors refer to errors that occur during the third and fourth stages of Abdullah's five-stage model of mathematical problem-solving, which involve transforming and processing the information presented in the problem. Specifically, process skills errors arise from inaccuracies in applying mathematical concepts and procedures, including selecting the appropriate mathematical operations or formulas, performing calculations, and interpreting the results. These errors can occur at various points during the problem-solving process. They may be influenced by factors such as the student's mathematical proficiency level, ability to apply mathematical concepts in context, and level of attention to detail. The study will identify process skills errors by analyzing students' problem-solving processes and the types of errors they make at each stage, using a framework based on Newman's Error Analysis.

Reading Comprehension Ability. Conceptually, It is understanding and interpreting what is being read. To understand written material accurately, there is a need to decode what the students read, make connections between what they read and what they already know, and think deeply about what they have read (Danesh & Nourdad, 2017). Operationally, it is defined as the capacity of grade 8 students to understand and extract meaning from written texts, particularly in word problems. Reading comprehension ability includes a range of skills, such as identifying critical information, making inferences, analyzing text structure, and drawing conclusions. In the context of solving word problems, reading comprehension ability refers to the ability of students to effectively read and understand the problem, identify the relevant information, and apply appropriate problem-solving strategies to arrive at a correct solution.

Reading Error. Conceptually, this is the error exhibited by the students when he/she cannot read the keywords or symbols written in the problem, and it will be classified as a reading error, preventing it from being processed further to correct problem-solving (Agustiani, 2017). Operationally, this is defined as any mistake made by Grade-8 students while reading and understanding word problems. Reading errors may include: misreading or misinterpreting critical information in the problem, failing to identify important details, making incorrect assumptions, or misunderstanding the meaning of specific vocabulary words. These errors may result from various factors, including poor reading comprehension skills, limited vocabulary knowledge, or difficulties processing and retaining information. Reading errors can negatively impact a student's ability to solve word problems accurately and efficiently and may lead to incorrect or incomplete solutions. In the study context, reading errors were identified and analyzed to understand

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better the specific challenges that Grade-8 students faced when solving word problems and to develop effective strategies for improving their problem-solving skills.

Transformation Error. Conceptually, this is the error exhibited by the students when he/she comprehends the question but cannot identify the operations or sequence of operations needed to solve the problem (Agustiani, 2017). Operationally, a transformation error is defined as an error made by grade 8 students when transforming information from a problem into a mathematical equation or solution. Transformation errors may include mistakes in translating words or phrases into mathematical symbols or operations, using incorrect formulas or procedures, or making errors in calculating or manipulating equations. These errors may result from various factors, including a lack of understanding of mathematical concepts, confusion about problem-solving strategies, or difficulty with basic arithmetic operations. Transformation errors can negatively impact a student's ability to solve word problems accurately and efficiently and may lead to incorrect or incomplete solutions. In the study context, transformation errors were identified and analyzed to understand better the specific challenges that Grade-8 students faced when solving word problems and to develop effective strategies for improving their problem-solving skills.

METHODOLOGY

Research Design

This study employed the quantitative research method, specifically the descriptive correlational research design, to examine the relationship between errors in problem solving and reading comprehension and analytical ability. A descriptive correlational research design was appropriate as it enabled the researcher to identify and describe the relationship between two or more variables, and to determine the extent to which they were related (Creswell, 2014).

Instrumentation

This study utilized three research instruments to address its research questions. Initially, the researcher used the Philippine Informal Reading Inventory (Phil-IRI), designed for Grade-8, to assess the reading comprehension proficiency of the participants. Phil-IRI is an assessment tool comprising graded passages to determine students' oral reading and reading comprehension performance. Subsequently, the researcher used Carter's (2009) Test of Logical Analysis to assess the analytical proficiency of the participants. This test, comprising 10 items, did not require specialized knowledge in vocabulary or mathematics but rather the ability to think analytically and follow a common-sense reasoning process to arrive at the answer. Moreover, the researcher used two-item standardized word problems sourced from the Regional Test Item Bank of Mathematics 8 to assess the accuracy of solving mathematical word problems. Newman's Error Analysis quantified the extent of error each participant committed through a scoring system.

Validation of Instrument

The validity of the test instrument is the degree to which a test accurately assesses the concept being evaluated. Furthermore, the efficacy of the research instrument refers to the accuracy and reliability of the instruments, data, and results. According to Brown and Ki (2013) assertion, internal and external factors can undermine the validity of research findings. As Brown and Ki (2013) stated, in cases where the chosen tool lacks specificity, researchers should endeavor to develop more precise measures to enhance efficacy.

The present study utilized standardized tests, namely the Phil-IRI, Test of Logical Analysis, and word problems sourced from the Regional Test Item in Mathematics 8, to ensure the validity and reliability of the research instrument.

Sampling Procedure

The methodology used involved using a purposive random sampling technique by the researcher. The study involved three sections of eighth-grade students from Talalora National High School *(formerly Independencia National High School)* during the School Year 2022-2023. The categorization of students into different levels was determined by their analytical proficiency, which are exceptional, very good, good, average, and below average. A random sampling technique ensured that the sample was representative of the population, whereby twenty percent of the students in each category were selected randomly. The sampling process was conducted with the aid of the school head and the concerned teachers. The inclusion of students in the study was based on their voluntary participation, and their consent was sought before their selection as a sample. The appropriateness of the sample size guaranteed significant statistical strength and precision in the data analysis.

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Data Gathering Procedure

This study aimed to examine the problem-solving errors made by students in correlation with their reading comprehension and analytical proficiencies. The research methodology involved a multi-step data collection process in addressing the research inquiries: Initially, a sample of eighth-grade students was chosen from the three sections of Talalora National High School to ensure the inclusivity and applicability of the results. The study gathered data on the respondents profiles, including their age, gender, reading comprehension, and analytical ability. Setting up these profiles played a crucial role in comprehending the attributes of the subjects and their probable impact on the errors manifested during the problem-solving process. A standardized test for reading comprehension was employed to evaluate the respondents reading comprehension ability. The test assessed the respondents proficiency in comprehending written text, aptitude in comprehending complex concepts, and capacity to extract pertinent information from word-based problem sets. Likewise, the analytical ability of the respondents was assessed through a standardized tool for evaluating analytical skills. The instrument, as mentioned above, assessed the respondents aptitude for critical thinking, logical reasoning, and applying mathematical principles in the context of problem-solving. Subsequently, the respondents were administered a series of word problems sourced from the regional test item bank to evaluate their problem-solving ability. The respondents were allotted 20 minutes to solve the problems and document their responses. In this stage, the errors made by the respondents were identified and classified. The identified errors underwent analysis along two distinct dimensions: reading comprehension and analytical ability. This analysis aimed to identify the domains in which students experienced challenges. The errors were categorized according to the type of errors committed, appropriate statistical analyses were performed to investigate the correlation between the profiles of the respondents and the errors manifested. The mentioned analyses encompassed the investigation of correlations, conducting chi-square tests, or utilizing other pertinent statistical techniques to determine the significance of the connection. The data-gathering procedure was conducted with a priority of ethical considerations. The study adhered to ethical guidelines by obtaining informed consent from respondents and their parents and ensuring their information's confidentiality. The study was conducted after obtaining permission from pertinent authorities, including schools. Recognizing specific constraints of the data collection process holds significant importance. The study focused on offering insights into the errors exhibited by eighth-grade students in solving word problems and their correlation with reading comprehension and analytical skills by adhering to this comprehensive data collection procedure. The results of this study could provide insights into educational approaches and measures aimed at improving students' problem-solving abilities.

Statistical Treatment of Data

The statistical treatment of data involved using various measures to describe and analyze the data collected in this study. The research utilized both descriptive and inferential statistics.

Frequency Counts and Percentages. These tools were used to describe the distribution of the demographic characteristics of the respondents such as, age, sex, reading comprehension level, analytical ability, and errors in problems solving. The frequency count provided the number of occurrences of the characteristics of the respondents, while the percentage represented the proportion of responses relative to the total number of responses.

Mean and Standard Deviation. These statistical tools were used to analyze the data on the respondents age. The mean provided an average age of the respondents, while the standard deviation indicated the degree of variation from the mean. This was used to describe the central tendency and variability of the data.

Chi-squared Test for Dependence. This statistical tool was used to examine the relationship between the respondents problem-solving errors and the level of reading comprehension and analytical ability. This test was used because the variables are categorical. Cramer's V and Contingency Coefficient were likewise computed to determine the strength of the relationship of the variables.

Ethical Consideration

Adherence to ethical considerations is crucial in any research project. Respondents were informed about the purpose and nature of the study, and informed consent and assent were obtained before they participated. The respondents anonymity was ensured by assigning codes instead of using their names. Moreover, confidentiality was maintained by storing the data securely and limiting access to only authorized personnel. The respondents were also assured that their information would be used solely for research purposes and not be shared with any unauthorized person or organization. These ethical considerations were strictly adhered to throughout the study to ensure the safety and well-being of the respondents.

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RESULTS AND DISCUSSION

Age and Sex of the Student-Respondents

Table 1: Age and Sex Distribution of Student-respondents

AGE	SEX					
	Male		Female		Total	
	f	%	*f*	%	*f*	%
12	0	0	1	8.33	1	5
13	7	87.5	8	66.67	15	75
14	1	12.5	3	25	4	20
Total	**8**	**100**	**12**	**100**	**20**	**100**
Mean	**13.125**		**13.167**		**13.150**	
SD	**0.3536**		**0.5774**		**0.4894**	

Table 1 presented the distribution of the sex of the respondents across different age groups. Many of the respondents was composed of individuals aged 13 years old, which represent 75 percent of the total sample. The remaining 25 percent is split between individuals aged 12- and 14-years old accounting to 5 percent and 20 percent respectively. In terms of sex, most of the sample is female, representing 60 percent of the total sample. The remaining 40 percent is male.

In terms of descriptive statistics, the mean age of males was 13.123 (SD = 0.3536), and the mean age of females was 13.167 (SD = 0.5774). The overall mean age was 13.150 (SD = 0.4894). The standard deviation for males was lower than that for females, which suggests that there was less variability in age among males than among females.

Reading Comprehension Ability of the Student-Respondents

Table 2: Reading Comprehension Ability of the Student-respondents

Reading Comprehension Level	Male		Female		Total	
	F	%	*f*	%	*f*	%
Independent Level	3	15	3	15	6	30
Instructional Level	2	10	6	30	8	40
Frustration Level	3	15	3	15	6	30
Total	**8**	**40**	**12**	**60**	**20**	**100**

The respondents reading comprehension abilities are crucial in studying error analysis in solving word problems. Table 2 presented the respondents reading comprehension abilities, assessed using a standardized test. Based on the results, three males and three females belong to the independent level, whereas two males and six females belong to the instructional level - in addition, three males and three females belong to the frustration level. Based on the findings in Table 2, the instructional level was the most prevalent among the respondents. Specifically, six female and two male participants were classified under this category, indicating that they possessed a certain degree of comprehension regarding the text, though requiring further assistance to achieve complete understanding. Six respondents, comprising three males and three females, were classified as having an independent level of comprehension, signifying their proficient understanding of the text without requiring assistance. However, three male and three female respondents were classified as being at the frustration level, indicating that they encountered difficulties comprehending the text despite receiving assistance.

These findings hold significance as they imply that the learners who participated in the study possess varying degrees of reading comprehension proficiencies that could influence their aptitude to solve word problems. Learners with an instructional proficiency level may encounter difficulty solving word problems requiring advanced cognitive abilities or involving complex vocabulary. On the other hand, individuals with an independent proficiency level may find it comparatively easy to comprehend the

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language and concepts that are elaborated in the word problems. Overall, Table 2 underscored the significance of considering respondents reading comprehension proficiencies when investigating their aptitude for solving word problems. By considering this variable, researchers and teachers can enhance their comprehension of the variables that impact respondents performance on word problems and identify areas that require supplementary assistance or guidance.

Analytical Ability of the Student-respondents

Table 3: Analytical Ability of the Student-respondents

Analytical Ability	Male		Female		Total	
	f	%	*f*	%	*f*	%
Exceptional	1	5	2	10	3	15
Very good	2	10	3	15	5	25
Good	3	15	3	15	6	30
Average	1	5	3	15	4	20
Below average	1	5	1	5	2	10
Total	**8**	**40**	**12**	**60**	**20**	**100**

The analytical ability of 8th-grade students in investigating error analysis when solving word problems was assessed using a standardized test, and the results are presented in Table 3. The results illustrated in Table 3 indicate that the respondents exhibit varying degrees of analytical proficiency, with specific individuals displaying outstanding ability while others require supplementary assistance and direction to develop their critical reasoning abilities. The findings indicate that three learners demonstrated exceptional analytical ability, one of whom was male, and the other two were female. It is likely that these individuals exhibit proficient critical thinking abilities and are capable of effectively analyzing complex data. The findings revealed that two males and three females were categorized as possessing a very good level of analytical ability, denoting their proficiency in effectively analyzing information. In addition, three males and three females were classified as having good analytical ability, implying their competence in analyzing information at a middle level. Conversely, the findings show that four respondents, one male and three females, were classified as possessing average analytical aptitude, implying that they may encounter difficulties comprehending complex data. Furthermore, the analytical ability of two respondents, specifically one male and one female, was below average. This finding implies that these individuals may require additional support and guidance to develop their critical thinking skills.

The data in Table 3 indicated a wide range of analytical proficiencies among the respondents, which could influence their aptitude for successfully solving mathematical word problems. The results of this assessment hold significance for researchers and teachers to consider when developing strategies to improve students' problem-solving skills and ability to analyze and interpret information.

The first problem statement centered on the profile of Grade-8 pupils regarding their age, gender, reading comprehension ability, and analytical ability during the process of word problem-solving. The results suggested that most respondents were 13 years old, comprising seven males and eight females within this age range—additionally, one female aged 12 and 1 male and three females aged 14. The mean age of male respondents was 13.125, whereas the mean age of female respondents was 13.167. The findings indicate that the respondents exhibited diverse levels of reading comprehension proficiency, with specific individuals being classified under the independent, instructional, and frustration level groups. Additionally, the study's respondents exhibited a wide range of analytical proficiencies, with specific individuals being classified as exceptional, very good, good, average, and below average.

The results of this study hold notable implications for educators and researchers who endeavor to improve the abilities of Grade-8 students in problem-solving. The results indicate that teachers must consider students' diverse range of reading comprehension and analytical skills when designing instructional materials and pedagogical approaches. By identifying students' strengths and weaknesses in various domains, teachers can effectively modify their instructional strategies to address the individual

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needs of every student. Moreover, the findings of this study serve as a basis for future studies into improving the proficiency of eighth-grade pupils in solving word problems, particularly in areas where they encounter difficulties. These insights may serve as a valuable reference for designing efficient pedagogical approaches and interventions to improve their ability to solve word problems.

Errors Exhibited by the Respondents along Reading Comprehension

Problem solving is a critical component of learning mathematics, and it involved various cognitive processes, including comprehension, transformation, process, and encoding. These processes are influenced by the reading comprehension level of the learner. The contingency table provided shows the relationship between problem-solving errors and reading comprehension ability. It highlights the four types of errors commonly committed by the learners in solving mathematical problems namely: comprehension errors, transformation errors, process skill, and encoding errors.

Problem-Solving Errors Exhibited by the Respondents along Reading Comprehension

Table 4: Problem-solving Errors Along Reading Comprehension

Reading Comprehension	**Problem Solving Errors**				
	Comprehension, Transformation, Process, & Encoding Errors	**Transformation, Process, & Encoding Errors**	**Process & Encoding Errors**	**No Error**	**Total**
Frustration Level	3	4	2	0	9
Instruction Level	0	1	4	0	5
Independent Level	0	0	0	6	6
Total	3	5	6	6	20

Comprehension error refers to the difficulty that students face in understanding the meaning of a question, even when they can read all the words in it. This error occurs during the second stage of problem-solving, which involves comprehending the textual material of the problem. Transformation error refers to the situation when a student understands the problem but cannot identify the operations or sequence of operations needed to solve the problem. These errors can include mistranslation of words or phrases into mathematical symbols, using incorrect formulas or procedures, or making mistakes in calculation or manipulation of equations.

On the other hand, process skill error refers to the error made by students when they can recognize the proper operations but need to learn how to carry out these operations correctly. This error occurs during the transforming and processing stages of mathematical problem-solving and results from inaccuracies in applying mathematical concepts and procedures. Finally, encoding error refers to inaccuracies in the recording or expressing a problem's solution, such as mistakes in transferring values from one operation to another, recording the result, or applying appropriate units of measurement or notation. It occurs when a student can solve a problem correctly but needs help to express it in a correct and proper written form.

The contingency table shows types of problem-solving errors made by student participants in relation to their reading comprehension levels. It can be observed that most problem-solving errors made were related to the combination of process skills and encoding errors (6 of 14 or 43%), followed by the combination of transformation, process skills, and encoding errors (5 of 14 or 36%), and all the problem-solving errors namely: comprehension, transformation, process, and encoding errors (3 of 14 or 21%). Individuals at the frustration level of reading comprehension made the most problem-solving errors, with 44% of the errors related to the combination of transformation, process, and encoding errors, while individuals at the instruction level of reading comprehension made the most process and encoding errors (80%). The students in the independent reading comprehension level did not make any problem-solving errors related to comprehension, transformation, process, and encoding indicating a high level of problem-solving ability.

Several studies have explored the different types of errors in problem solving. For example, one study found that students who struggled with comprehension error were more likely to have difficulty with transformation error as well (Wang et al., 2022). Another study found that process skills error was the most common type of error made by middle school students during problem

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solving (Lin et al., 2021). In terms of addressing these errors, one study found that explicitly teaching problem-solving strategies can help reduce transformation errors and improve overall problem-solving performance (Abdullah et al., 2015). Another study found that providing students with feedback on their problem-solving strategies can help reduce both transformation and process skills errors (Bailey et al., 2015). Furthermore, some studies have explored the relationship between problem-solving errors and other factors such as working memory and motivation. For example, one study found that students with lower working memory were more likely to make comprehension errors during problem solving (Gupta & Zheng, 2020). Another study found that students who were more motivated to learn were less likely to make transformation errors (Chang et al., 2017).

Problem-Solving Errors Exhibited by the Respondents along Analytical Ability

The contingency table shows the relationship between analytical ability of the student respondents and the problem-solving errors they have committed namely: Comprehension, Transformation, Process, and Encoding Errors. The table is divided into five levels of analytical ability: Exceptional, Very Good, Good, Average, and Below Average, with the total number of student respondents being 20.

Table 5: Problem-solving Errors Along Analytical Ability

	Problem Solving Errors				
Analytical Ability	**Comprehension, Transformation, Process, & Encoding Errors**	**Transformation, Process, & Encoding Errors**	**Process & Encoding Errors**	**No Error**	**Total**
Exceptional	0	0	0	3	3
Very good	0	1	2	2	5
Good	1	1	3	1	6
Average	2	1	1	0	4
Below Average	0	2	0	0	2
Total	3	5	6	6	20

From the table, we can see that most students in the good analytical ability level made process and encoding errors (60%), while all the students in the below average level made transformation, process, and encoding errors. Students with average analytical ability showed more comprehension, transformation, process, and encoding errors (50%) and transformation, process, and encoding errors (25%). Students in the exceptional level analytical ability committed no error. Overall, students in the good analytical ability level committed the most error (5 of 14 or 36%), with those belonging to the average analytical ability level coming in at close second with 4 of 14 (29%). The most common error made were related to process and encoding (43%) followed closely by the combination of transformation, process and encoding errors (36%).

Analytical ability is an important factor in problem-solving, as it affects a student's ability to understand and analyze problems, formulate hypotheses, and make decisions. It is evident that students with higher analytical ability tend to commit fewer errors in problem-solving. This is supported by a study conducted by Rodzalan and Saat (2015), which found that students with high analytical ability exhibited better problem-solving skills compared to those with lower analytical ability. Furthermore, a study by Chukwuyenum (2013) found that students with higher analytical ability demonstrated better performance in problem-solving tasks that require mathematical skills.

In contrast, a study by Setiawan and Supiandi (2018) showed that analytical ability was not a significant predictor of problem-solving performance among undergraduate students. Additionally, a study by Ramos and Hayward (2018) found that although analytical ability was positively correlated with problem-solving performance, other factors such as motivation and self-efficacy also played a significant role.

Regarding different types of problem-solving errors, it can be observed that most students exhibited process and encoding errors. This is consistent with previous studies that showed that encoding errors are a common type of error in problem-solving

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tasks (Abdullah et al., 2015; Riastuti et al., 2017). Moreover, a study by Son and Fatimah (2019) found that students who exhibit more encoding errors in problem-solving tasks tend to have lower academic achievement compared to their peers.

Relationship Between the Reading Comprehension Ability and Problem-Solving Errors Exhibited by the Respondents

The chi-squared test was conducted to examine the association between the reading comprehension ability and problem-solving errors committed by the student respondents. The test yielded a significant result, $X^2(6, N = 20) = 26.726$, $p < 0.001$, indicating that there is a significant relationship between the levels of reading comprehension and problem-solving errors. Cramer's V coefficient of 0.817 suggests a strong relationship between these variables.

The contingency table in Table 5 shows that the students with reading comprehension in the frustration level had the highest number of problem-solving errors with a total of 9 out of 14 (64%), while those with reading comprehension in the instruction level demonstrated 5 out of 14 (36%) problem-solving errors. The students with reading comprehension in the independent level committed no problem-solving errors. In terms of specific problem-solving errors, the comprehension, transformation, process, and encoding errors were most prevalent among the students in the frustration level, followed by transformation, process, and encoding errors among students in the instruction level.

Table 6: Chi-squared Test on the Relationship Between the Reading Comprehension Ability and Problem-solving Errors

Comprehension Ability		**Problem Solving Errors**				
		Comprehension, Transformation, Process, & Encoding Errors	**Transformation, Process, & Encoding Errors**	**Process & Encoding Errors**	**No Error**	**Total**
Frustration Level	Count	3	4	2	0	9
	Expected count	1.35	2.25	2.7	2.7	9
	% of total	15 %	20%	10	0	45 %
Instruction Level	Count	0	1	4	0	5
	Expected count	0.75	1.25	1.5	1.5	5
	% of total	0 %	5 %	20 %	0 %	25 %
Independent Level	Count	0	0	0	6	6
	Expected count	0.9	1.5	1.8	1.8	6
	% of total	0%	0 %	0%	30 %	30 %
Total	Count	3	5	6	6	20
	Expected count	3	5	6	6	20
	% of total	15 %	25 %	30 %	30 %	100 %
X^2	**n**	**df**	**p-value**	**Cramer's V**		
26.726	20	6	< .001	0.817		

These results suggest that there is a significant relationship between reading comprehension and problem-solving errors, with the frustration level exhibiting the most errors. This may indicate that students who struggle with reading comprehension may also struggle with problem-solving, and that interventions targeting reading comprehension may also improve problem-solving skills.

Related studies in recent years support these results including a study by Kingsdorf and Krawec (2014), which found that students with weaker reading skills exhibited more errors in math problem-solving. Similarly, a study by Boonen and colleagues

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(2016) found that students with lower reading comprehension skills also had lower scores on math problem-solving tasks. A study by Fuchs and colleagues (2019) also found a link between reading comprehension and math problem-solving, with students who scored higher on a reading comprehension task performing better on a math problem-solving task.

On the other hand, a study by Geary and colleagues (2012) found that while reading comprehension was related to math problem-solving, it was not a significant predictor after controlling for other factors such as working memory and processing speed. A study by Zhang and colleagues (2018) found that while reading comprehension was related to mathematical problem-solving, it was only a weak predictor of performance. Finally, a study by Passolunghi and colleagues (2019) found that while there was a relationship between reading comprehension and math problem-solving, this relationship was mediated by working memory.

These findings suggest that reading comprehension plays a vital role in problem-solving and that students with lower comprehension levels may struggle with different aspects of problem-solving. However, further research is needed to explore the causal relationship between reading comprehension and problem-solving ability.

Relationship Between the Analytical Ability and Problem-Solving Errors Exhibited by the Respondents

The chi-squared test was conducted to determine whether there is a significant association between analytical ability and problem-solving errors. The results show that the chi-squared value is $X^2(12, N = 20) = 19.967$, $p < .068$. This shows that statistically, there is no significant association between analytical ability and problem-solving errors at 0.05 level of significance. However, the contingency coefficient is 0.707, which indicates a moderate association between the two variables.

The contingency table presented in Table 6 represented the relationship between analytical ability and different types of problem-solving errors. In terms of the relationship between analytical ability and problem-solving errors, the results show that those with exceptional analytical ability did not commit any problem-solving errors. Those with "Good" analytical ability exhibited the highest number of problem-solving errors (5 of 14 or 36%) while those with "Average" analytical ability committed the highest number of problem-solving errors related to a combination of comprehension, transformation, process, and encoding (2 of 3 or 67%). The students with "Below Average" analytical ability showed the highest problem-solving error related to a combination of transformation, process, and encoding (2 of 5 or 40%).

Table 7: Chi-squared Test on the Relationship Between the Analytical Ability and Problem-solving Errors

Analytical Ability		**Problem Solving Errors**				
		Comprehension, Transformation, Process, & Encoding Errors	**Transformation, Process, & Encoding Errors**	**Process & Encoding Errors**	**No Error**	**Total**
Exceptional	Count	0	0	0	3	3
	Expected count	0.45	0.75	0.9	0.9	3
	% of total	0%	0%	0%	15%	15 %
Very good	Count	0	1	2	2	5
	Expected count	0.75	1.25	1.5	1.5	5
	% of total	0%	5%	10%	10%	25%
Good	Count	1	1	3	1	6
	Expected count	0.9	1.5	1.8	1.8	6
	% of total	5 %	5%	15 %	5%	30%
Average	Count	2	1	1	0	4
	Expected count	0.6	1	1.2	1.2	4
	% of total	10%	5%	5%	0%	20%

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Below Average	Count	0	2	0	0	2
	Expected count	0.3	0.5	0.6	0.6	2
	% of total	0%	10%	0%	0%	10 %
Total	Count	3	5	6	6	20
	Expected count	3	5	6	6	20
	% of total	15%	25%	30%	30%	100%

X^2	**n**	**df**	**p-value**	**Contingency Coefficient**
19.967	20	12	0.068	0.707

These findings are contradictory with previous studies that have shown a strong relationship between analytical ability and problem-solving skills (Toraman et al., 2020; Tam et al., 2019). Additionally, studies have shown that problem-solving errors can be attributed to various factors, such as cognitive load (Sweller, 2010), metacognitive processes (García et al., 2016), and working memory capacity (Wiley & Jarosz, 2012).

However, some studies have supported these findings, suggesting that there may not be a strong relationship between analytical ability and problem-solving skills (Heong et al., 2011). Additionally, some studies have suggested that the relationship between analytical ability and problem-solving skills may be influenced by other factors (Kaymakci & Can, 2021) such as motivation (Tee et al., 2018) and domain-specific knowledge (Kattou et al., 2013).

The findings of the chi-squared test suggest that there is a strong association between analytical ability and problem-solving errors. However, further research is needed to better understand the nature of this relationship and the other factors that may influence it.

CONCLUSIONS

Based on the notable findings presented in the study, the researcher has drawn the following conclusions:

1. Most of the participants involved in the study were 13 years old, with females representing 60% of the overall population. The male respondents exhibited a marginally lower average age in contrast to their female participants, and a narrower range of age distribution was observed among males relative to females. This implies that it is necessary to consider age and gender as variables in interpreting the findings.
2. The instructional level was the most prevalent among the respondents, with six females and two males classified under this category. However, some respondents encountered difficulties comprehending the text despite receiving assistance, as evidenced by their classification under the frustration level.
3. Most errors encountered during problem-solving activities are related to the combination of process skills and encoding errors. Transformation, process skills, and encoding errors closely followed this. The study revealed that individuals with exceptional analytical skills exhibited fewer errors. In contrast, those with below-average analytical skills demonstrated a greater tendency to commit errors related to transformation, process, and encoding.
4. The statistical analysis using the chi-squared test of association revealed a significant correlation between reading comprehension levels and the frequency of problem-solving errors. Furthermore, the importance of the relationship between these two variables was found to be strong.
5. There was no statistically significant association between analytical ability and problem-solving errors, but a moderate association between the two variables was observed.

In general, the results underscored the significance of considering distinct individual differences, such as age, gender, and analytical ability, when assessing aptitudes in reading comprehension and problem-solving. Furthermore, the outcomes indicated that endeavors to enhance comprehension and problem-solving abilities should concentrate on addressing particular error related to process skills and encoding.

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RECOMMENDATIONS

Based on the conclusions drawn, the researcher offers the following recommendations:

1. Researchers and educators should consider age and sex differences in reading comprehension when interpreting the results of studies. This can help better understand the factors contributing to reading comprehension and tailor interventions to specific groups.
2. Teachers and educators should pay attention to the needs of students who encounter difficulties comprehending the text, even when they receive assistance. Different instructional approaches may be necessary for students at different comprehension levels, and teachers should adapt their teaching strategies accordingly.
3. Educators and researchers should pay particular attention to the combination of process skills and encoding errors when designing reading comprehension interventions. This can reduce the number of errors students make and improve their comprehension.
4. Future studies should consider exploring the relationship between reading comprehension and problem-solving errors in more detail, including investigating potential mediating variables that may affect this relationship.
5. While there was no statistically significant association between analytical ability and problem-solving errors, the moderate association observed suggests that this is an area for further investigation. Future studies could examine the impact of interventions designed to improve analytical ability on problem-solving errors in reading comprehension.

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