

Error pattern analysis of the Mathematics problem solving of grade 10 learners

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Article History

Received on 1 May 2024

1st Revision on 14 May 2024

2nd Revision on 18 May 2024

3rd Revision on 24 May 2024

4th Revision on 12 June 2024

Accepted on 13 June 2024

Abstract

Purpose: This study investigates respondents' error patterns in mathematics problem-solving, their impact on problem solving, and their attitudes towards mathematics, examining the relationship between these factors.

Research methodology: This study used a convergent mix method design to analyze data from 80 Grade 10 students at Matucay National High School, focusing on error patterns in problem solving and the relationship between learners' performance and their attitudes towards mathematics.

Results: The study revealed that students excel in problem solving in mathematics, but their errors are mainly in formulation. They need to improve their reading comprehension, conceptual knowledge, and reasoning skills. The study also found that students' attitudes towards mathematics were influenced by their sex but not their problem-solving performance.

Limitations: The study involved grade 10 students, and the findings may be different if participants were at a different grade level (e.g., grade 8, grade 9, etc.). In addition, other disciplines of mathematics problem-solving can also be explored for the comparison of results.

Contribution: Enhances the understanding of the relationship between students' attitudes towards mathematics and error patterns committed in calculating mathematics problem-solving. Emphasizing integrating the relative day-to-day experience of students and engaging in activities to boost motivation and learning outcomes is useful in shaping effective strategies for students, teachers, administrators, and officials.

Novelty: This study emphasizes the significance of real-world experiences in mathematics problem-solving to improve learning outcomes and attitudes, offering valuable insights for educators, administrators, policymakers, and students in developing effective learning strategies and highlighting the connection between positive attitudes and mathematical problem-solving experiences.

Keywords: *Error pattern analysis, Mathematics problem solving, Convergent mix method, Attitude towards Mathematics, Academic Performance*

How to Cite: Campanilla, N. S., & Mendoza, C. R. (2024). Villages Error pattern analysis of the Mathematics problem solving of grade 10 learners. *Journal of Social, Humanity, and Education*, 4(4), 245-262.

1. Introduction

Mathematics is important in our daily lives. It addresses issues that require analysis, computation, and other mental abilities. The importance of mathematics in human life spans all spheres of endeavor and educational levels. Making Mathematics a required subject from elementary school to college is a sign that people understand its practical usefulness, especially given the rapid development of technology, commerce, industry, and agriculture.

Many students have trouble with mathematics, particularly problem solving. They still need to understand mathematics because it is essential to everyday life. They must be capable of problem-solving because they are crucial for the growth of human skills. Mathematical problems require higher-order thinking abilities and increased intellectual capacity that can grasp the full significance of the subject. As a result, students frequently make mistakes when dealing with mathematics, particularly when addressing problems.

The activities of processing the knowledge used in the process of addressing problems vary in problem solving. Before arriving at a solution, students must go through several steps in the problem-solving process. According to Newman's theory, there are five steps in solving mathematical problems: (a) reading errors are the ability of students to read mathematical problems given and identify sentences and mathematical symbols used; (b) comprehension errors are the ability of students to understand math problems; (c) transformation errors are the ability of students to determine the method of mathematical solution; (d) process skill errors are the ability of students to perform process skill errors in mathematics correctly; and (e) encoding errors are the ability of students to write encoding errors according to the question. Polya (1985) states that in problem solving, there are four steps to be taken: (1) to understand the problem, (2) to plan for completion, (3) to do the problem according to the plan, and (4) to re-examine if all steps are done. Students may solve problems more quickly and methodically, even when they are presented with varying degrees of difficulty and guided by the phases outlined by Polya and Newman. However, some students struggle during certain periods and are unable to overcome these challenges.

Furthermore, underlying mistakes were repeatedly made by the students when solving word problems, especially when trying to determine what model they would be using. Currently, Veloo, Krishnasamy, and Wan Abdullah (2015) investigate the errors made by 10th grade students when working with symbols, graphs, and problem-solving in mathematics. A total of 315 students made certain common mistakes, including conceptual, sloppy problem-solving, and value errors. In addition, the researchers identified several causes of inaccuracies. However, the writers impliedly introduced pupils to the importance of graphs in everyday life. In 2014, Loc researched the errors made by 12th grade pupils when computing integrals, and in 2015, he solved challenges using the coordination method in space. According to the findings, the students made several errors in the linked themes. He also suggested that student mistake analysis would assist teachers in recognizing student errors, modifying teaching methods, and conducting in-depth studies on pertinent themes.

In addition, one of the most frequent mistakes is not being able to come up with definite and exact formulae that will be used in solving word problems. According to a study by Triliana and Asih (2019) entitled "Analysis of students' errors in solving probability based on Newman's error analysis" students' errors in solving probability based on Newman's error analysis frequently occurred in the stages of reading, comprehension, and process skills. Students made errors in selecting the formula to solve the tasks, understanding what the tasks were asked about, and determining the events. Additionally, Jupri and Drijvers (2016) observed that the difficulty in formulating mathematical models seems to be caused by students' lack of understanding and ability to connect mathematical concepts from different mathematical strands, such as connecting Algebra and Geometry. Likewise, according to Haerani, Novianingsih, and Turmudi (2021), showed that the students' errors in solving word problems were including comprehension, transformation, and process skill errors. In addition, Lee and Han (2018) showed that teaching methods based on mathematical problem-posing activities had a more positive effect on students' mathematics achievement and the affective characteristics of mathematics than the teaching method that focuses on problem solving. It investigates the frequency and types of errors, explains their causes, and provides recommendations for instructional interventions to help students improve their problem-solving skills.

Word problem-solving is typically challenging for students and poses a threat to them. In honesty, pupils can solve mathematical problems, but the information they have in their heads is difficult to comprehend. Because he was unable to recognize the specific information requested, the learners were unable to adapt the facts to novel circumstances. Additionally, most math professors lack the necessary

credentials to teach the subject. As a result, a variety of teaching and learning processes affects how challenging a subject is to learn.

Based on the General Weighted Average (GWA) last School Year 2022-2023 of Matucay National High School, the Overall GWA of Grade 10 students towards mathematics is 84.50, which landed the lowest rank in terms of all the subject areas, indicating that mathematics has the least mastered competencies of all the essential competencies that should be mastered by grade 10 learners. This is also supported by their least-mastered competencies in the problem-solving part of the lessons, wherein their understanding of solving word problems is low, which is reflected in their examinations' item analysis. Another reason is that the students hated mathematics for a reason, and they find it very boring, based on the perceptions of Grade 10 students towards mathematics last year by other grade-level researchers.

Given the foregoing importance of problem solving in mathematics, this study aimed to determine the respondents' common errors and error patterns in mathematics problem solving. Additionally, it sought to ascertain the impact of respondent profile characteristics, such as sex, economic status, and parental educational attainment, on mathematics problem-solving. It also aimed to determine the attitudes of learners towards solving mathematics problems. This served as an avenue to provide solutions and answers to educators for building or creating new ways of teaching and learning strategies, such as innovations and new interventions that could improve students' attitudes and performance in solving mathematics word problems. This also gave teachers ways to integrate real-life examples into their lessons to make learners easily connect with the given set of word problems, which was really what they were experiencing in the present or what they had experienced in the past events of their lives.

1.1 Research Questions

1. What is the profile of learners in terms of the following variables?
 - a. Sex
 - b. Economic Status
 - c. Parent's Highest Educational Attainment
 - d. Performance Grade in Mathematics
2. What is the attitude of learners towards mathematics problem-solving?
3. What is the performance of learners in mathematics problem-solving?
 - a. Number sense
 - b. Algebra
 - c. Geometry
 - d. Trigonometry
 - e. Statistics and Probability
4. What error patterns can be analyzed from the mathematical problem-solving of the learners?
5. Is there a significant relationship between the profile and performance of learners in mathematics and their attitude towards mathematics problem solving?
6. Is there a significant relationship between the performance of learners in mathematics problem-solving and their attitude towards mathematics problem-solving?

1.2 Hypotheses

1. There was no significant relationship between the profile and performance of learners in mathematics and their attitude towards mathematics problem solving.
2. There was no significant relationship between the performance of the learners in mathematics problem-solving and their attitude towards mathematics problem-solving?

2. Literature Review

The following text was taken from several works of writing relevant to the research in terms of error pattern analysis and attitudes towards mathematics as impacted by students' problem-solving skills.

2.1 Profile and Mathematics Problem Solving

Errors in Mathematics can be factual, procedural, or conceptual and may occur for a few reasons. Identifying the reasons why students make mistakes in solving mathematical problems is important. Some of these reasons go beyond their profiles, such as gender, educational attainment, and economic status. Dagyar and Demirel (2015) found no significant variation in the reflective thinking skills of male and female pupils. On the other hand, Nurhayanti and Usodo (2020) show that the male subject does not understand the problem correctly, as he does not mention all the information in the problem, whereas the female subject shows that the subject understands the problem by mentioning all the information in the problem. This is corroborated by Shalihah (2015), who found differences between male and female students in issue-solving, specifically in planning problem-solving. Male students are less thorough and obtain incorrect calculation results, while female students are more careful in performing calculations and obtaining the correct results.

According to OECD (2016), parents of students with low academic success are more likely to be uneducated. Families with a high level of education are more likely to provide their children with high-quality academic support (Kudari, 2016). Furthermore, according to Harju-Luukkainen, Vettenranta, Wang, and Garvis (2020), family-related factors such as parents' educational level, values, and expectations have a considerable impact on children's early skills and subsequent educational outcomes. Demir, Kılıç, and Ünal (2010) investigated the effects of student and school factors on mathematics achievement. The findings revealed that students with higher economic, social, and cultural status performed better in mathematics. Furthermore, Reardon (2018) noted that there is a significant disparity in student accomplishments based on financial level. Thus, students' socioeconomic backgrounds influence their performance (Perry & McConney, 2010).

2.2 Relationship between Attitudes and Attainment in Mathematics Problem Solving

Students' attitudes toward problem-solving are directly related to their achievement. Furthermore, their attitude toward mathematics problem-solving will reveal how they will take it, whether positive or negative, and will subsequently reflect on their performance. Shah et al. (2023) proposed that learners' attitudes influence their mathematical achievement. In addition, a study conducted in Malaysia discovered that employing a cooperative learning strategy improved students' attitudes toward mathematics, leading to improved performance (Zakaria, Chin, & Daud, 2010). An analysis conducted by Khaneghahi, Nasripour, and MahmoudZehi (2022) also showed that there is a positive and significant relationship between academic motivation and students' academic enthusiasm.

The intensity of this relationship is very strong, and academic motivation can predict academic enthusiasm. Almagro and Edig (2024) revealed a clear connection between positive computer attitudes and active social media engagement, indicating the effectiveness of motivated strategies in improving math learning outcomes. Interestingly, although computer attitudes alone did not significantly influence these strategies, social media engagement had a notable impact. This was also supported by Mohammed, Philip, and Labaran (2024), who found that the use of social media has a significant impact on students' learning abilities, writing skills, and academic performance. However, some investigations have yielded slightly different results. According to Marchiş (2013), learners' attitudes toward mathematics are related to their problem-solving abilities. According to Mensah, Okyere, and Kuranchie (2013), people with good attitudes toward Mathematics are more likely to express their excitement to tackle mathematical problems. Bart, Can, and Hokanson (2020) found that the relationship between high creativity and academic achievement varied between eighth- and eleventh-graders.

High Mathematics and reading achievement are related to high creativity among both eighth- and eleventh-grade students, but with small effect sizes. According to Inoncillo (2024), both mathematics test anxiety and numerical anxiety predict mathematics achievement [$F(2, 94) = 8.450, p < 0.005$] through multiple regression analysis. Furthermore, the results showed that numerical anxiety highly predicted mathematics achievement in the two dimensions of mathematics anxiety ($b = -8.710, p = 0.001$). Thus, inversely significant relationships exist between mathematics test anxiety and mathematics achievement, and between numerical anxiety and mathematics achievement. Moreover,

Mathematics test anxiety and numerical anxiety when combined significantly predicted mathematics achievement. Furthermore, between Mathematics test anxiety and numerical anxiety, numerical anxiety predicted mathematics achievement when taken individually. However, Ganzon and Edig (2022) indicated that time management is manifested most of the time, and self-directed learning is often observed. Moreover, their academic performance in mathematics is not proficient. Furthermore, time management and self-directed learning were found to have no significant relationship with academic performance in mathematics. Thus, time management and self-directed learning did not significantly predict academic performance in mathematics.

2.3 Academic Performance in Mathematics and Mathematics Problem Solving

Students' comprehension of mathematics problem solving has a positive and significant influence on their mathematics learning outcomes. Students who are adept at problem solving typically have better academic performance in mathematics. According to Sari et al. Sari, Yaniawati, and Kartasasmita (2019), students' mathematical problem-solving comprehension influences their mathematics learning outcomes. When used in classroom instruction, the problem-solving approach can significantly increase knowledge and performance in mathematics (Albay, 2019). The findings of Karamık (2023) demonstrated that problem-solving strategies improved students' mathematics achievement. Likewise, Sinaga, Sitorus, and Situmeang (2023) supported the idea that students' comprehension of mathematics problem solving has a favorable and significant influence on their mathematics learning outcomes. Thus, in conclusion, there is a big effect on how learners perceive mathematics and how they perform problem sets towards it on their academic performance. Macaso and Dagohoy (2022) found a significant positive relationship between attitude in mathematics, reflective thinking skills, and performance in mathematics. However, it was revealed that there is a negative, non-significant relationship between problem-solving skills and mathematics performance. Furthermore, it was discovered that attitude toward mathematics significantly predicted performance in mathematics.

2.4 Theoretical Underpinnings of the Study

The strategy for reviewing journals is to conduct a literature search and collect articles using the keywords reasoning, mathematical reasoning, and reasoning in school learning that relate to the underpinning theories that impact the error pattern made by students towards mathematics problem-solving. According to Creswell and Clark (2017), the initial task in any research study is to search for, select, weigh, and read the literature. A literature review is essential for conducting research, as research cannot be separated from scientific literature. Nuraini et al. Nuraini, Kusmayadi, and Fitriana (2019) concluded that students could solve problems well. Based on Schoenfeld Theory, senior high school students showed that the stages of problem solving were reading, analysis, exploration, planning, and implementation. However, students were not able to prove the answers obtained by looking for other problem-solving methods. Most students use problem-solving strategies taught only in their school. Students did not explore other problem-solving strategies. The research paradigm invented by Allen Newell and Herbert A. Simon in the late 1950s has dominated the study of problem solving for more than three decades. However, in the early 1990s, problem-solving ceased to drive research on complex cognition (Ohlsson, 2012). Problem-based learning theory is a strategy that organizes Mathematics teaching around problem-solving activities while also providing students with opportunities to think critically, present their own creative ideas, and communicate mathematically with colleagues (Rézio, Andrade, & Teodoro, 2022).

The literature, studies, and theoretical underpinnings provide a foundation for the conceptualization of the research paradigm presented in Figure 1.

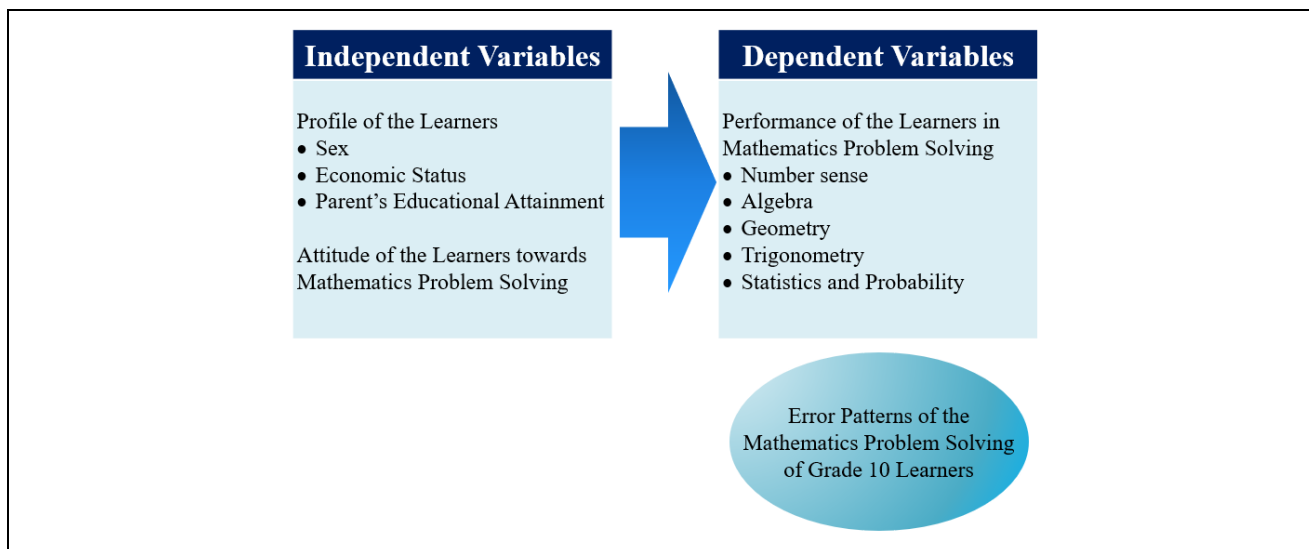


Figure 1. Paradigm of the study

2.5 Scope and Delimitation

This study was limited to the analysis of error patterns in mathematics problem solving that were commonly committed by Grade 10 students. The study determined the common errors committed by the respondents and the error patterns in mathematics problem solving. Additionally, it sought to ascertain the impact of respondent profile characteristics, such as sex, economic status, and parental educational attainment, on mathematics problem-solving. It also determines the attitude of learners towards solving mathematical problems. The respondents of the study were Grade 10 students who were currently enrolled at Matucay National High School, and the study was conducted during the second quarter of the school year 2023-2024. The school was located along the National Highway in Matucay, Allacapan, Cagayan.

3. Methodology

This chapter discusses the methodologies of the study, such as research design, participants, instrumentation, and data analysis.

3.1 Research Design

A convergent mixed-methods design was employed to gather the data required for the study. The design included both quantitative and qualitative data, which were collected and analyzed, and then compared to determine whether the data confirmed or disconfirmed each other.

This study used a descriptive-correlational design. This was a descriptive design because frequency and percentage distribution were used to present the profile variables of the respondents, such as sex, economic status, educational attainment of both parents, and performance grade in mathematics. In addition, a weighted mean was used to present respondents' attitudes towards mathematics and the error patterns committed in solving mathematical problems.

This was correlated because the comparison of the error patterns in problem-solving of the respondents when grouped according to profile variables was determined. It was also used to determine the relationship between the performance of learners in mathematics problem-solving and their attitude towards mathematics problem-solving.

3.2 Participants

The respondents of the study were Grade 10 students of Matucay National High School who were officially enrolled during the school year 2023-2024. The school is located along the Maharlika Highway in Matucay, Allacapan, and Cagayan, and has a total enrollment of 935 learners for the current school year. The school is famous within the congressional district since its campuses are separate from

each other, particularly in senior high school and junior high school areas. Furthermore, simple random sampling was used to identify the respondents of the study.

3.3 Instrumentation

Written permission was secured from the School Division Superintendent of the Schools Division Office of Cagayan to obtain full cooperation from the respondents. As soon as permission was granted, the researchers personally administered the questionnaires and facilitated the elicitation of further reliable data and additional information.

Upon completion of the form to obtain basic demographic information and study instruments, the researchers personally collected and entered the data gathered in an Excel Spreadsheet for data cleaning and for easier computation.

In addition, the main data gathering instrument used in the study was Mathematics Problem Solving and a survey questionnaire. The researchers created a checklist to determine the learners' profiles. The error patterns committed by the learners were determined and analyzed using a mathematics problem-solving test, which is a teacher-made test that was made sure of its validity and reliability. The attitude of the learners toward learning mathematics was determined using the Attitudes towards Mathematics Inventory (ATMI) by Tapia and Marsh (2004), which was modified by Ndlovu (2017). The ATMI was further modified by the researchers to suit learners.

3.4 Data Analysis

Multivariate analysis of variance was used to analyze the data, which involved the observation and analysis of more than one statistical variable at a time.

Frequency count and percentage distribution were used for the data on the learner's profile, particularly on sex, economic status, parents' highest educational attainment, and performance grade in mathematics.

To assess the learners' attitude towards mathematics, individual- and category-weighted mean computations were applied using a 5-point Likert scale. The interval and interpretation of the scale are as follows:

Scale	Range	Descriptive Value	Level of Attitude
5	4.20 – 5.00	Strongly Agree	Highly Positive
4	3.40 – 4.19	Agree	Positive
3	2.60 – 3.39	Undecided	Neutral
2	1.80 – 2.59	Disagree	Negative
1	1.00 – 1.79	Strongly Disagree	Highly Negative

In addition, the performance of the learners in problem-solving in mathematics and its disciplines, particularly Number Sense, Algebra, Geometry, Trigonometry, Statistics, and Probability, was determined through frequency count and percentage distribution. Moreover, a weighted mean and a 5-point Likert scale were applied to further determine their attainment of mathematics problem-solving skills by discipline and overall summary, with the intervals and interpretation shown below.

Description	By Discipline	Overall
Outstanding	13 – 15	61 – 75
Very Satisfactory	10 – 12	46 – 60
Satisfactory	7 – 9	31 – 45
Fairly Satisfactory	4 – 6	16 – 30
Did Not Meet Expectations	0 – 3	15 and below

The weighted mean and percentage distribution were used to present the errors committed by the respondents in problem-solving. In addition, a rubric of the pointing system for problem solving was used to clearly identify the committed error patterns not only by each branch of mathematics, which includes Number Sense, Algebra, Geometry, Trigonometry, and Statistics and Probability, but also a summary of it. The pointing system for scoring word problems is as follows:

Steps in Problem Solving	Range
Given	1 point
Unknown	1 point
Formula	1 point
Solution	1 point
Final Answer	1 point
Total	5 points

Thematic Analysis was used to identify, categorize, analyze, and interpret the error patterns committed by the respondents in solving mathematics problems. The Pearson product-moment correlation was used to determine the relationship between the different variables in the study. Statistical software was employed to analyze the data gathered in the study, and it was interpreted at a significance level of 0.05.

4. Results and Discussions

4.1 Profile Variables

Sex

The distribution of learners by sex is presented in Table 1a. This shows that there were more male learners, as revealed by their frequency of 41, or 51.3 percent, than female learners. This finding means that Grade 10 learners at Matucay National High School are male-dominated. This is in line with the Philippine population facts as of the January 2023 census, which shows that 50.8 percent were male and 49.2 percent were female. This finding is also supported by the enrolment data for SY 2023-2024, wherein there were more male learners enrolled in Grade 10 than female learners.

Table 1. Distribution of Learners in terms of Sex

Sex	Frequency (n=80)	Percentage
Male	41	51.3
Female	39	48.7

Economic Status

The distribution of the learners in terms of their economic status is presented in Table 1b. As shown in the table, 18 or 22.5 percent have a family monthly income of ₱5,000 and below. There are 17 or 21.2 percent whose family's monthly income ranges from ₱20,001.00 - ₱30,000.00 and ₱10,001.00 to ₱15,000.00; 10 or 12.5 percent of family's monthly income ranges from ₱5,001.00 to ₱10,000.00, while 9 or 11.2 percent have a family monthly income of ₱15,001.00, ₱20,000.00, and ₱30,001.00, respectively. Furthermore, the family monthly mean income is 3.7 with a standard deviation of 1.7, which means that most of the learners' family monthly income belongs to the minimum wage earners group since most of the learners' parents are farmers within Allacapan, which is the main source of living and occupation, and that is also because Cagayan is known as the rice granary of the region.

Table 2. Distribution of Learners in terms of Economic Status

Family Monthly Income	Frequency (n=80)	Percentage
₱30,001.00 and above	9	11.2
₱20,001.00 - ₱30,000.00	17	21.2
₱15,001.00 - ₱20,000.00	9	11.3
₱10,001.00 - ₱15,000.00	17	21.3
₱5,001.00 - ₱10,000.00	10	12.5

₱5,000.00 and below	18	22.5
	<i>Mean = 3.7</i>	<i>SD = 1.7</i>

Parents' Highest Educational Attainment

Table 1c shows the distribution of learners in terms of the parents' highest educational attainment. It is apparent from the table that most fathers, comprising 29 or 36.2 percent, finished their secondary grade, while 22 or 27.5 percent finished their elementary grade, and 18 or 22.5 percent completed their bachelor's degree in college. In addition, 9 or 11.2 percent reached a certain level in college, and extreme educational attainment had a frequency of 1 or 1.3 percent on a master's unit and a master's degree.

It is also evident in the same table that mothers have a high regard for education and could help their children with their assignments and advance lessons. This is because most of the learners' mothers, as proven by the frequency of 31 or 38.7 percent, completed secondary school; 20 or 25 percent graduated with a bachelor's degree in college education, 15 or 18.7 percent reached a certain level in college, and 13 or 16.3 percent finished elementary school, while learners' mothers who graduated with a master's degree had a frequency of 1 or 1.3 percent. In addition, it shows that the learners' father's educational attainment has a mean of 4.1 and a standard deviation of 5.6, and their mothers' educational attainment has a mean of 4.4 and a standard deviation of 1.4.

This finding means that most of the learners' parents have reached the educational level where they can guide and support their children in their studies because the home environment is as important as what goes on in the school. Moreover, they can provide strong scaffolding to learners by helping them with assignments or homework and guiding them in making decisions in their lessons to arrive at desirable results. Furthermore, learners whose parents are not adequately literate are disadvantaged because these days, parents are required to assist their children with assignments and projects that are supposed to be done at home. This reflects that most of the learners' parents are elementary school graduates, wherein the students' abilities in terms of doing their math homework are limited by themselves because they have already achieved higher academic attainment than their parents, which limits their ability to give and share knowledge about it.

Table 3. Distribution of Learners in terms of Parents' Highest Educational Attainment

Educational Attainment	Father		Mother	
	Frequency(n=80)	Percentage	Frequency(n=80)	Percentage
Elementary Level	0	0.0	0	0.0
Elementary Graduate	22	27.5	13	16.3
High School Level	0	0.0	0	0.0
High School Graduate	29	36.2	31	38.7
College Level	9	11.2	15	18.7
College Graduate	18	22.5	20	25.0
With Master's Units	1	1.3	0	0.0
Graduate in Master's Degree	1	1.3	1	1.3
	<i>Mean = 4.1</i>	<i>SD =5.6</i>	<i>Mean = 4.4</i>	<i>SD = 1.4</i>

Performance Grade in Mathematics

Table 1d shows the distribution of the learners' performance grades in mathematics. As presented, 45 or 56.2 percent of the learners were Very Satisfactory in their performance grade in mathematics, ranging from 85 to 89; 31 or 38.8 percent were Outstanding, ranging from 90 to 100 while 4 or 5 percent were Satisfactory in Mathematics performance grade in mathematics, ranging from 80 to 84, in accordance with the K to 12 Grading System. This finding means that most of the learners have a Very Satisfactory performance in mathematics, with a mean of 88.4 and a standard deviation of 3.3. This implies that learners have average performance in mathematics. This is a clear indication that low

mathematics achievement is a perennial problem in the Philippine educational system. Moreover, this finding is supported by the Philippine International Student Assessment (PISA) results, which show that the Philippines ranked 67th out of 140 countries in terms of the quality of Mathematics and Science education in the 2015–2016 Global Competitiveness Report of the World Economic Forum, and 79th out of 138 in the 2016–2017 data.

Table 4. Distribution of Learners in terms of Performance Grade in Mathematics

Description	Scale	Frequency (n=80)	Percentage
Outstanding	90-100	31	38.8
Very Satisfactory	85-89	45	56.2
Satisfactory	80-84	4	5.0
Fairly Satisfactory	75-79	0	0.0
Did Not Meet Expectations	Below 75	0	0.0
Mean = 88.4 (Very Satisfactory)		SD = 3.3	

4.2 Perception Results

Learners Attitude towards Mathematics

Learners' attitudes towards mathematics are presented in Table 2. As shown, learners have a highly positive attitude towards mathematics since they see it as important in everyday life (4.51). This is why they want to develop their mathematical skills since they got a great deal of satisfaction from solving a mathematical problem with 4.20 and 4.31 mean, respectively. This finding shows that learners are eager to learn more and discover new concepts in mathematics in order to strengthen their skills. Consequently, assigning more tasks led to greater engagement and interest in learning.

Further, they also have a positive attitude towards mathematics because they believe that it helps them develop their minds and teaches them to think (4.08). Mathematics is a very interesting subject (3.80), which is why the challenge of mathematics appeals to them (3.75), arousing them to solve new sets of problems in mathematics (3.78). Furthermore, they believe that studying mathematics helps them with problem-solving in other subjects (3.88), and they find it easier to learn than the other subjects (3.84) because they have a lot of self-confidence when it comes to mathematics (3.96). That is why they prefer to solve math problems than to write an essay (3.43) because they can solve mathematics problems quite easily (3.93). Likewise, they do not hate mathematics (3.41) and are not dull and boring (3.69). They also think that studying mathematics does not make them feel nervous or uneasy (3.42) because their minds do not go blank, and they are able to think clearly when working with numbers (3.88). This then implies that the learners like to learn new things that interest them on their own, since mathematics is very interesting to them and boosts their self-confidence. Moreover, they prefer to work on new sets of problems to learn how to solve them, and sometimes they prefer difficult problems because they enjoy trying to figure them out rather than writing an essay.

On the other hand, their attitude is in a neutral and balanced state when it comes to mathematics because it is not one of the most feared subjects (3.21) and does not scare them at all (3.21). That is why they cannot decide if they would like to avoid mathematics courses in the future (2.86). This finding shows that mathematics is a very interesting subject, and learners are sometimes confused during class. Therefore, new strategies or techniques should be employed during the teaching-learning process to engage them properly.

Furthermore, the overall weighted mean indicates that learners have a positive attitude toward the given statements in mathematics. This implies that the learners of Matucay National High School have a positive attitude towards mathematics because their personal goals and objectives are associated with their mathematics learning, as indicated by their responses. Aryana (2010) concluded that learners who feel more confident about themselves are not apprehensive, and they have higher academic achievement in contrast to those who do not have confidence in themselves. In the same vein, Naderi, Abdullah, Aizan, Sharir, and Kumar (2009) noted that research consistently shows a positive correlation between how people value themselves and the level of their academic attainments. According to them, learners

who feel confident generally achieve more, whereas those who lack confidence in themselves achieve less. This finding implies that if learners believe that what they are learning in their mathematics subject reflects their expectations and goals for the topic, they will have a favorable attitude about the subject.

Table 5. Learners Attitude towards Mathematics

Statements	Weighted Mean	Descriptive Value
1. I want to develop my mathematical skills	4.40	Highly Positive
2. I get a great deal of satisfaction out of solving a mathematical problem	4.31	Highly Positive
3. I believe Mathematics helps develop the mind and teaches a person to think	4.08	Positive
4. Mathematics is important in everyday life	4.51	Highly Positive
5. Mathematics is not one of the most feared subjects	3.21	Neutral
6. My mind doesn't go blank, and I am able to think clearly when working with numbers	3.88	Positive
7. Studying Mathematics does not make me feel nervous/uneasy	3.42	Positive
8. I do not hate Mathematics subject	3.41	Positive
9. Mathematics does not scare me at all	3.21	Neutral
10. I can solve Mathematics problems quite easily	3.93	Positive
11. I have a lot of self - confidence when it comes to Mathematics	3.96	Positive
12. I am not confused in a math class	3.44	Positive
13. I learn Mathematics easily than the other subjects	3.84	Positive
14. Mathematics is not dull and boring	3.69	Positive
15. I like to solve new problems in Mathematics	3.78	Positive
16. Mathematics is very interesting to me	3.80	Positive
17. I would not like to avoid Mathematics courses in the future	3.14	Neutral
18. The challenge of math appeals to me	3.75	Positive
19. I believe studying of math helps me with problem solving in other subjects	3.88	Positive
20. I would prefer to solve math problems than to write an essay	3.43	Positive
Overall weighted mean = 3.73		Positive

4.3 Problem Solving Results

Number Sense

The distribution of learners' performance in mathematics problem solving, particularly in Number Sense, is reflected in Table 3. As can be seen from the table, most of the learners (49, or 61.25 percent) have excellent scores ranging from 13 to 15, while 27 or 33.75 percent have Above Average scores ranging from 10 to 12, and 4 or 5 percent have an average score ranging from 7 to 9. The mean score of the learners was 12.98 with a standard deviation of 2.05, which means that the learners performed excellently in problem solving in Mathematics on Number Sense. This indicates that the students have exceptional performance in the Number Sense and that their fundamental understanding of number concepts, numerous representations, and operations is completely developed.

Algebra

The apparent in Table 3 is the distribution of learners' performance in problem solving in Mathematics on Algebra. The table shows that most of the learners' scores were excellent, with a frequency of 44 or 55 percent ranging from 13 to 15. Likewise, 25 or 31.25 percent of learners' scores are Above Average scores ranging from 10 to 12, while 11 or 13.75 percent are average scores ranging from 7 to 9. Moreover, the mean score of the learners was 12.24 with a standard deviation of 2.24, which means that the learners' scores were above average. This implies that the students were very experienced in solving problem sets in Algebra and had a solid foundation in it.

Geometry

Learners' performance in mathematics problem-solving based on geometry is presented in Table 3. According to the findings, most learners (65 or 81.25 percent) had excellent scores ranging from 13 to 15, while 10 or 12.50 percent had average scores ranging from 7 to 9, and 5 or 6.25 percent had above-average scores ranging from 10 to 12. Furthermore, the learners' mean score was 13.63 with a standard deviation of 2.56, indicating excellent scores. This suggests that the students were quite familiar with solving problem sets in geometry and had a thorough understanding of their fundamental concepts, shape representations, and operations.

Trigonometry

Table 3 shows the performance of students in trigonometry mathematics problem solving. According to the data, the majority of students with a frequency of 64 or 80 percent have excellent scores ranging from 13 to 15, 13 or 16.25 percent have average scores ranging from 7 to 9, and 3 or 3.75 percent have above-average scores ranging from 10 to 12. Furthermore, the mean score of the students was 13.51, with a standard deviation of 2.53, indicating that their results were good. This indicates that the students are well-versed in solving trigonometry problem sets and have good comprehension of their essential ideas, trigonometric ratios, and operations.

Statistics and Probability

Table 3 depicts the distribution of learners' performance in mathematics problem-solving, focusing on Statistics and Probability. The table shows that many students (46 or 57.50 percent) have excellent scores ranging from 13 to 15, while 17 or 21.25 percent have above-average scores ranging from 10 to 12 and average scores ranging from 7 to 9. The learners' mean score was 12.41, with a standard deviation of 2.79, indicating that they excel at problem-solving in Mathematics on Statistics and Probability. This means that the students performed exceptionally well in Statistics and Probability and had a thorough comprehension of the operation of possibilities and probabilities, data collection, and representations.

Summary

The summary of learners' performance towards mathematics problem solving, particularly on Number Sense, Algebra, Geometry, Trigonometry, and Statistics and Probability, is also shown below, in which the learners' mean score in their problem solving in Mathematics is 64.76 with a standard deviation of 8.87, which indicates that the learners have excellent performance towards it. This conclusion implies that Matucay National High School students are good at problem solving in mathematics because they have a strong foundation in basic concepts, representations, and operations.

Table 6. Performance of Learners towards Mathematics Problem Solving

Description	Scale	Number Sense		Algebra		Geometry		Trigonometry		Statistics & Probability		Scale	Overall Summary	
		f	%	f	%	f	%	f	%	f	%		f	%
Excellent	13 – 15	49	61.3	44	55	65	81.3	64	80	46	57.5	61	76.3	
Above Average	10 – 12	27	33.8	25	31.3	5	6.3	3	3.8	17	21.3	46	15	18.7
Average	7 – 9	4	5	11	13.8	10	12.5	13	16.3	17	21.3	31	4	5.0
Poor	4 – 6	0	0	0	0	0	0	0	0	0	0	16	0	0
Very Poor	0 – 3	0	0	0	0	0	0	0	0	0	0	30	0	0
		Mean = 12.98 SD = 2.05		Mean = 12.24 SD = 2.24		Mean = 13.63 SD = 2.56		Mean = 13.51 SD = 2.53		Mean = 12.41 SD = 2.79		Overall Mean = 64.76 (Excellent Performance) SD = 8.87		

4.4 Error Pattern Results

Learners' Error Patterns Committed in Solving Mathematics Problem

Table 4 presents the common error patterns committed by learners when solving mathematics problems. The table reveals that there were four major parts wherein the learners committed their error patterns in solving mathematics problems: formulation errors, computational errors, analysis errors, and solution errors. Most of the learners' errors in mathematics problem solving fall under formulation errors, particularly the incorrect substitution and incorrect usage of formulas or equations when solving mathematics problems, with a frequency of 97, which ranks first. It also includes an incorrect translation of expressions with a frequency of 79, ranking fourth. Another error pattern committed by learners is computational error. These errors include neglecting units, signs, and symbols, which rank second with a frequency of 89; not checking solutions for accuracy with a frequency of 77, which ranks fifth; and using incorrect operations with a frequency of 83, which ranks third. An additional error committed by the learners was in the analysis, particularly in misinterpreting problems with a frequency of 64, which ranked sixth, failing to identify the given with a frequency of 60, which ranked eighth; misidentifying variables with a frequency of 55, which ranked ninth; and assigning variables with a frequency of 43, which ranked tenth. Finally, being unable to provide the complete format of an answer under solution error ranked seventh with a frequency of 62. The findings indicate that learners struggle with formulation errors when solving mathematics problems, implying that precise substitution and proper use of formulas or equations through precise translation of terms and expressions are required to avoid neglecting units, signs, and symbols in problem solving. This then suggests that learners must first thoroughly comprehend the meaning of the questions before proceeding with mathematical processing and calculation to develop a comprehensive translation of terms and expressions or equations, which can lead to a complete solution, and finally arrive at the correct and final answer.

Table 7. Error Patterns Committed by the Learners in Solving Mathematics Problem

Error Patterns	Frequency*	Rank
<i>Formulation Errors</i>		
Incorrect substitution and incorrect usage of formula or equations	97	1
Incorrect translation of expressions	79	4
<i>Computational Errors</i>		
Using incorrect operations	83	3
Neglecting units, signs and symbols	89	2
Not checking solution for accuracy	77	5
<i>Analysis Errors</i>		
Misinterpreting problems	64	6
Failed to identify the given	60	8
Misidentifying variables	55	9
Assigning variables	43	10
<i>Solution Error</i>		
Unable to provide the complete format of an answer	62	7
<i>No Errors</i>	5291	

4.5 Correlation Results

Correlations Between the Learners' Attitude in Mathematics and Profile Variables

The study hypothesized that there would be no significant relationship between learners' profile variables and their attitudes towards mathematics. Thus, based on the results of the correlation test shown in Table 5a, the computed coefficients of learners' profile variables, particularly sex and learners' attitudes towards mathematics, have associated probabilities of less than 0.05. In this regard, the null hypothesis was rejected.

The correlation analysis also revealed that sex is significantly related to learners' attitudes towards mathematics, as shown by the computed correlation value of 0.196 with a probability of 0.041. This

finding implies that gender disparities between males and females represent a varied attitude toward mathematics. Female students (coded as 2) regarded mathematics as a beneficial subject, leading to higher academic accomplishment compared to male students (coded as 1). Furthermore, this conclusion is consistent with the findings of Dan'inna (2017), that there is a favorable relationship between sex and learners' attitudes about learning Mathematics.

Table 8. Correlations Between the Learners' Attitude in Mathematics and Profile Variables

Variables	Correlations	p-value	Statistical Inference
<i>Learners' Attitude towards Mathematics</i>			
<i>Learners' profile variables</i>			
Sex	0.196	0.041	Significant
Economic Status	-0.131	0.123	Not Significant
Parents' Highest Educational Attainment (Mother)	0.100	0.189	Not Significant
Parents' Highest Educational Attainment (Father)	-0.057	0.307	Not Significant
Performance Grade in Mathematics	-0.056	0.311	Not Significant

*tested at 0.05 level of significance

Correlations Between the Learners' Performance in Mathematics Problem Solving and Profile Variables

The study hypothesized that there is no significant relationship between learners' profile variables and their performance in mathematics problem-solving. Thus, based on the results of the correlation test shown in Table 5b, the computed coefficients of the profile variables and learners' attitudes towards mathematics were not associated with any probabilities less than the significance level of 0.05. In this regard, the null hypothesis was accepted.

The correlation analysis also revealed that learners' profile variables, which include sex, economic status, parents' highest educational attainment, and performance grade in mathematics, were not significantly related to the learners' performance in mathematics problem solving, as shown by the computed correlation values and probabilities in the table.

Table 9. Correlations Between the Learners' Performance in Mathematics Problem Solving and Profile Variables

Variables	Correlations	p-value	Statistical Inference
<i>Learners' Performance in Mathematics Problem Solving</i>			
<i>Learners' profile variables</i>			
Sex	0.065	0.284	Not Significant
Economic Status	0.011	0.462	Not Significant
Parents' Highest Educational Attainment (Mother)	0.050	0.328	Not Significant
Parents' Highest Educational Attainment (Father)	-0.059	0.302	Not Significant
Performance Grade in Mathematics	-0.042	0.357	Not Significant

*tested at 0.05 level of significance

Correlations Between the Learners' Performance in Mathematics Problem Solving and Learners' Attitude towards Mathematics

The study hypothesized that there is no significant relationship between learners' attitudes towards mathematics and their performance in mathematics problem solving. Thus, based on the results of the correlation test shown in Table 6, the computed coefficients of the profile variables and learners' attitudes towards mathematics have associated probabilities less than the significance level of 0.05. The correlation analysis also revealed that learners' performance in mathematics problem solving is significantly related to their attitude towards mathematics, as shown by the computed correlation value

of 0.196, which means that the higher the learners' attitude towards mathematics, the higher the performance of the learners in mathematics problem solving, and the lesser the learners' attitude towards mathematics, the lesser the performance of the learners in mathematics problem solving. This supports the fact that if learners like to learn mathematics, their performance will be excellent, and if otherwise, their performance will be poor. Furthermore, it has a probability of 0.00, which means that the null hypothesis is rejected. Thus, there is a relationship between learners' attitudes towards mathematics and their performance in mathematics problem-solving. This is parallel to the study of Mazana, Suero Montero, and Olifage (2019), who found that students initially exhibit a positive attitude towards mathematics, but their attitude becomes less positive as they move forward to higher levels of education. Thus, it indicates that the attitude of learners towards learning mathematics is related to their performance when solving mathematics problems involving the disciplines of Number Sense, Algebra, Geometry, Trigonometry, and Statistics and Probability.

Table 10. Correlations Between the Learners' Performance in Mathematics Problem Solving and Attitude towards Mathematics

Variables	Correlations	p-value	Statistical Inference
<i>Learners' Attitude towards Mathematics</i> <i>Learners' Performance in Mathematics Problem Solving</i>	0.465	0.000	Significant

**tested at 0.05 level of significance*

5. Conclusion

5.1 Synthesis

The primary objective of this study was to investigate the error patterns committed by learners and relate them to their attitudes towards learning mathematics. This study on the error pattern analysis of learners towards mathematics problem solving was limited to Grade 10 learners of Matucay National High School, Allacapan, Cagayan, for the School Year 2023-2024. Basically, it determined the profile of the learners based on their sex, economic status, parents' highest educational attainment, performance grade in mathematics, performance score in solving mathematics problems through a reliability and validity test, and the attitude of learners towards mathematics, which was limited to the results of the survey using the Attitudes towards Mathematics Inventory, which was modified by Ndlovu (2017). The study also tested the relationship between learners' profile variables, their performance in solving mathematics problems, and their attitude towards mathematics.

Multivariate analysis of variance was used to analyze the data, which involved the observation and analysis of more than one statistical variable at a time. For the data on learners' profiles, simple frequency counts, percentage distributions, and weighted means were used. When all data were gathered, they were tabulated and statistically analyzed. For the assessment of the performance score of the learners towards solving mathematics problems and the attitude of the learners towards mathematics, individual and category-weighted mean computation was applied using a 5-point Likert scale. Pearson product-moment correlation was used to determine the relationships between the different variables in the study. Similarly, statistical software was used to analyze the data gathered in the study, and it was interpreted at a significance level of 0.05.

The study found that the Grade 10 learners of Matucay National High School are male dominated, and most of their economic status lies under a family's' monthly income of below five thousand pesos (₱5,000.00). Moreover, most of their fathers and mothers completed basic education, wherein they could guide and support their children in their studies, whereas most learners had Very Satisfactory performance in mathematics.

On the other hand, the study also found that the learners agreed that their personal goals and objectives are associated with their mathematics learning, since the mathematical concepts they learn can assist them in finding an excellent career. They also agreed that they try to perform well in mathematics evaluation as compared to other learners, and they prepare well for mathematics tests, assignments, and

projects. Further, they also agreed that it always concerns them whenever they are in mathematics class and makes them anxious about how they will perform better.

Likewise, the study found that learners' performance in mathematics problem-solving is excellent. The results showed that learners have a strong foundation in basic concepts, representations, and operations towards disciplines in mathematics, including number sense, algebra, geometry, trigonometry, and statistics and probability, and that learners struggle with formulation errors in solving mathematics problems, requiring precise substitution and translation of terms and expressions. Understanding the meaning of questions is crucial for a comprehensive translation, leading to a complete solution and correct answers.

Finally, it also showed that the learners' attitude towards mathematics was found to be significantly related to sex, and their performance score in solving mathematics problems was not associated with any of their profiles. It was also found that the performance score of learners in solving mathematics problems was significantly related to their attitudes towards mathematics.

5.2 Conclusion

In conclusion, this study of students' attitudes towards mathematics revealed several key findings. First, students generally have a positive attitude towards mathematics and demonstrate proficiency in solving problems and understanding the key concepts in the subject. However, they tend to struggle with formulation errors in solving mathematical problems, requiring precise substitution and translation of terms and expressions. Understanding the meaning of questions is crucial for a comprehensive translation, leading to a complete solution and correct answers. This suggests that they need to improve their reading, understanding ideas, and processing math problems more deeply. The research also revealed that learners had a favorable attitude toward mathematics because they enjoyed complicated thinking and the challenges of mathematics. The study also indicated that learners' attitudes toward mathematics were substantially related to gender, whereas their performance scores in solving mathematics questions were unrelated to any of their profiles. Surprisingly, the study discovered that students' attitudes had a significant impact on their ability to answer certain mathematical problems. Overall, the findings emphasize the importance of a comprehensive understanding of mathematics problems and the significance of a positive attitude toward achieving success in the subject.

5.3 Recommendations

In light of the findings and conclusions of this study, the following actions are highly recommended:

1. Mathematical teachers should actively engage students in math activities, including problem-solving drills. They should provide a systematic method of solving mathematical word problems to avoid error patterns. Also, they should create specialized Mathematics programs that will assist students in understanding and correcting the faults they make, such as "Math Clinic" and "Math Day," to provide targeted support for students in identifying and rectifying their mistakes. These programs can offer individualized assistance, practice sessions, and feedback to enhance students' understanding and proficiency in problem solving, ultimately fostering a positive learning environment that promotes growth and mastery in mathematics.
2. School authorities and administrators should pay attention to the challenges mathematics teachers face. Valuable insights into designing instructional techniques and strategies to improve students' mathematical proficiency and address individual learning challenges indicate the need for development in reading comprehension, conceptual understanding, and mathematical processing.
3. Future researchers must include other profile variables in their study that may affect the errors committed in problem solving, such as allowance, teacher profile, and instructional materials used in mathematics instruction.
4. Mathematical teachers should consider implementing differentiated instruction to cater to the diverse learning needs of students. By providing varied instructional approaches, materials, and assessments, teachers can better support students in overcoming their individual challenges and enhancing their problem-solving skills.
5. Encourage peer tutoring and collaborative learning among students, which can be beneficial for improving problem-solving skills. Peer tutoring allows students to learn from each other, discuss

different approaches to problem solving, and receive peer support to address errors and misconceptions.

6. School authorities should prioritize ongoing professional development opportunities for mathematics teachers. Training sessions, workshops, and seminars focused on effective teaching strategies, error analysis, and student engagement can help teachers enhance their instructional practices and better support students in problem-solving.

Acknowledgment

The researchers are immeasurably grateful for the approval, assistance, and support provided by the institutions and all other entities that made this study possible.

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