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Critical Analysis and Problem-Solving Performance in Trigonometry Among College Students

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ABSTRACT

Problem-solving is believed to be the essence of mathematics learning. Problem-solving in Trigonometry is crucial for developing critical thinking and analytical skills, spatial reasoning, and a strong foundation for advanced mathematics. It also has practical applications in various fields, making understanding the factors influencing problem-solving skills essential. This study aims to investigate the specific role of critical thinking in trigonometry problem-solving performance. This study determined the critical analysis of mathematical translation and identifying appropriate formulas. On the other hand, the problem-solving performance was measured in terms of Polya's framework, which included understanding the problem, devising a plan, carrying out a plan, and looking back. The study utilized a Descriptive-correlation research design to determine the significant relationship between the two variables. A summative test was used as the data-gathering tool to assess the participants' performance. The study participants were thirty-four (34) randomly selected college students at a particular state university in Oriental Mindoro. The data were analyzed using Mean, frequency-percentage, and Pearson's r. The study's results revealed a significant relationship between the level of critical analysis and the level of performance in Trigonometry.

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1. INTRODUCTION

Problem-solving is a skill one must possess. It is a skill that helps solve word problems by integrating mathematical concepts in a real-life scenario. Problem-solving is a mathematical task that may provide intellectual challenges for enhancing students' mathematical understanding and development. The primary objective of teaching mathematical problem-solving is to equip students with the skills to solve real-life problems and apply mathematical knowledge to practical situations [1].

Polya [2] identified four problem-solving principles: understanding the problem, making a plan, executing a plan, and looking backward. Understanding the problem indicates a concrete understanding of the problem, from what is being asked to what is known and what is unknown. Making a plan includes coming up with a strategy on how he will solve the problem. Planning could include listing givens, visualizing the problem, identifying possible formulas, and solving more straightforward related problems. Besides the main plan, alternatives should also be prepared. The plan made beforehand will be executed. Once the plan does not work out, the alternatives come into play. If the plans still appear not to be working, return to the second principle and reconsider planning. Looking back involves finding a way to check one's answer. The solving process will be tested to see whether the conditions provided in the problem are met.

Despite its significance, problem-solving is widely recognized as one of the most challenging aspects of mathematics education. Many students struggle with problem-solving [3]. Students encounter difficulties in problem comprehension [4], [5], especially when the problem requires a combination of operations and solutions [6]. Various factors influence problem-solving performance. Guven and Cabakcor [7] identified resources, heuristics [8], metacognitive knowledge, and self-perception [9] as key influences on students' problem-solving abilities. Poor problem-solving performance could also be attributed to ineffective instruction [10], poor reading comprehension [4][11], decoding the problem [12], reading difficulty [13], and lack of knowledge about principles, rules, and processes in mathematics [14].

In line with Framing's [15] research, student engagement is essential for effective education. Regardless of the learning format (face-to-face, blended, or virtual), engaged students' enthusiasm, a sense of belonging, deep learning, self-regulation, active involvement, and autonomy. Engagement is a powerful catalyst for academic success, positive learning outcomes, and student satisfaction.

Trigonometry, a specialized area of Mathematics, focuses on the relationships between the sides and angles of triangles [16]. Its wide-ranging applications in architecture, science, medicine, engineering, astronomy, forensics, geography, and marine biology make it a significant interest [17], [18]. Moreover, trigonometry is integrated into various mathematical models, from logarithmic to hyperbolic tangent functions [19]. Given its importance, mastering Trigonometry is crucial for students as it can benefit their future careers.

Problem-solving in trigonometry can significantly enhance students' learning outcomes and skills. Problem-based learning is more effective than traditional instruction in improving students' problem-solving abilities and attitudes toward trigonometry [20]. Jumina et al. [21] found a strong correlation between problem-solving learning methods and trigonometry performance.

However, students may struggle with certain areas, such as proving trigonometric identities, due to misconceptions and confusion about algebraic properties [22]. Usman and Hussaini [23] describe Trigonometry as a difficult, abstract mathematics area. Zakariah et al. [24] identified various errors in solving mathematical problems, ranging from writing to oral to computational errors. Similarly, Orhun [25] found that students often fail to develop a deep understanding of trigonometric concepts and tend to apply rules without critical thinking mechanically.

Critical analysis is vital for solving trigonometry problems, but many students struggle [26]. Research suggests that strong critical analysis skills lead to better problem-solving performance, unique approaches, and improved logical thinking and memory in trigonometry [27]. However, many students face challenges in understanding problems, providing arguments, identifying relevant information, and formulating equations [28].

To address these setbacks mentioned, the researchers want to determine the relationship between the level of critical analysis in terms of mathematical translation and identifying appropriate formulas in the level of performance in Trigonometry, particularly right triangle trigonometry, in terms of understanding the problem, devising a plan, carrying out the plan and looking back at the work, and how these relate to each other.

This study aimed to determine the correlation between critical analysis and the performance in Trigonometry of selected college students. Specifically, this study answered the following questions.

1. What is the level of critical analysis of the participants?
2. What is the level of problem-solving performance in trigonometry for the participants?
3. Is there a significant relationship between the level of critical analysis and the problem-solving performance in trigonometry for the selected college students?

2. METHOD

The study utilized a descriptive-correlational research design. Descriptive research describes the characteristics of the population and the research subject without covering why it happens [29]. In this study, the respondents' level of problem-solving skills and their level of performance in trigonometry were determined. Correlational research design, on the other hand, looks at the relationships between two variables without manipulating or controlling any of the variables [29]. This study investigated the correlation between the participants' level of critical analysis and their problem-solving performance in Trigonometry.

The study was conducted in a state university in Southern Luzon, Philippines. Thirty-four (34) randomly selected students taking Trigonometry subjects participated in the study. The selection was done using the fishbowl method.

A self-made summative test was used to measure the respondents' critical analysis skills and problem-solving performance in trigonometry. The questionnaire has two parts. The first part is a multiple-choice test that measures the level of critical analysis in terms of translating mathematical statements and identifying appropriate formulas. Meanwhile, the second part of the questionnaire contained two problem-solving questions with four sub-questions each to assess the level of performance in problem-solving. The scores were categorized into four: 0-1(Poor), 2-4 (Fair), 5-7 (Satisfactory), 8-10 (Very Satisfactory). The instrument underwent validation and reliability tests ($\alpha = 0.87$) before its utilization.

Due to COVID-19 restrictions, the data were gathered online via Google Forms. The respondents were given two hours to answer the questionnaire. After the given time, the test questionnaires were retrieved. The results were then checked, tabulated, analyzed, and interpreted. The data gathered were analyzed using descriptive and inferential statistics. Arithmetic Mean was used to describe problem-solving skills and performance in Trigonometry. Frequency and percentage were used to express the respondents' relative frequency and percentage of responses regarding problem-solving skills and performance in trigonometry. Pearson's r was used to determine the relationship between higher-order thinking skills and the level of the participant's problem-solving performance in Trigonometry.

Certain ethical considerations were considered to ensure that the study was conducted properly. First, permission to conduct the study was secured. Then, respondents' consent was solicited. Participants were also informed about the purpose, benefits, and risks behind the study before they agreed or declined to join. They were also informed of the right to withdraw their participation in the study. Confidentiality of the information and anonymity were also guaranteed among them.

3. RESULTS AND DISCUSSION

This section presents the results of the data analysis conducted by the researchers. The results were presented in a way that answered the research questions that had previously been stated.

3.1. Level of Critical Analysis in terms of:

3.1.1 Mathematical Translation

Table 1 shows the level of critical analysis in terms of mathematical translation. Thirteen students obtained scores of 2-4, with a percentage of 38.24% interpreted as fair. Four (4) respondents got a score of 0-1, with a percentage of 11.76% interpreted as poor. The mean value is 5.18, which is interpreted as satisfactory. This implies that the respondents have the cognitive skills to translate mathematics.

Table 1. Level of Critical Analysis in Mathematical Translation

Score	***f***	***%***	***Description***
8-10	9	26.47	Very Satisfactory
5-7	8	23.53	Satisfactory
2-4	13	38.24	Fair
0-1	4	11.76	Poor
Mean	**5.18**		**Satisfactory**

This result parallels the findings of Hagena et al. [30] that reading comprehension is a promising approach for strengthening the modeling thread to build a real-world model and enhancing overall mathematical modeling. Furthermore, according to Reys et al. [31], mathematical problem-solving can assist students in deepening their comprehension of concepts, developing critical thinking and reasoning skills, working in groups, cooperating, and improving their general capacity to solve real-world problems.

3.1.2 Identifying Appropriate Formulas

Table 2 shows the level of critical analysis in terms of identifying appropriate formulas. As reflected in the table, 17 respondents obtained scores of 5-7, with a percentage of 50% interpreted as satisfactory. Further, ten students gave a very satisfactory performance, while seven gave a satisfactory performance. The mean value of 6.06 showed satisfaction in identifying appropriate formulas. This implies that the respondents judged the problems presented, which led them to identify an appropriate formula to solve the problem.

Table 2. Level of Critical Analysis in Identifying Appropriate Formulas

Score	***f***	***%***	***Description***
8-10	10	29.41	Very Satisfactory
5-7	17	50	Satisfactory
2-4	7	20.59	Good
0-1	0	0	Poor
Mean	**6.06**		**Satisfactory**

Like Huda et al.'s findings [32], this approach could boost individuals' willingness to tackle math problems and their determination and confidence in their abilities. It might further enhance their understanding of problem-solving techniques, the value of organized approaches, and the flexibility of multiple solutions. Additionally, it could improve their ability to select and implement effective strategies for tackling mathematical challenges.

3.2. Level of Problem-Solving Performance in Trigonometry in terms of:
3.2.1 Understanding the Problem

Table 3 shows that 24 respondents obtained scores 8-10, with a percentage of 70.59% interpreted as outstanding. While six scored 5-7 (satisfactory) and four scored 2-4 (fair), the mean value of 8.47 was interpreted as very satisfactory. This implies that the student-respondents could comprehend the problem, which was the first step in solving the problem.

Table 3. Level of Problem-solving Performance in Understanding the Problem

Score	*F*	%	*Description*
8-10	24	70.59	Very Satisfactory
5-7	6	17.65	Satisfactory
2-4	4	11.76	Fair
0-1	0	0	Poor
Mean	**8.47**		**Very Satisfactory**

These results are parallel to the study of Alghonaim [33], which states that understanding the problem involves the capacity to respond appropriately to textual information. Like this, reading interventions in the classroom allow students to participate in critical reflection, comprehend material, and use reason to produce sufficient responses in comprehension.

3.2.2 Devising a Plan

As shown in Table 4, a frequency of 23 respondents obtained scores of 8-10, with a percentage of 67.65% interpreted as very satisfactory, while 11(32.35%) manifested satisfactory performance. The mean score of 8.27 indicated the respondents were very satisfied with devising a plan to solve the problem. This implies that the respondents were able to positively picture an illustration that might help them solve the problem.

Table 4. Level of Problem-solving Performance in terms of Devising a Plan

Score	*f*	%	*Description*
8-10	23	67.65	Very satisfactory
5-7	11	32.35	Satisfactory
2-4	0	0	Fair
0-1	0	0	Poor
Mean	**8.27**		**Very Satisfactory**

Like Cerbito's [34] findings, this study reveals that Trigonometry problem-solving errors stem from four main issues: inability to extract information from questions, mismatches between problem models and sketches, difficulty choosing appropriate solutions or formulas, and lack of conceptual understanding of chosen methods.

3.2.3 Carrying out the plan.

Table 5 shows a frequency of 22 respondents, equivalent to 64.715, who got scores 8-10 interpreted as very satisfactory. It could also be noticed that 11 (32.35%) performed satisfactorily, while one student scored 2-4, which signified fair performance. The mean value of 8.21 denoted that the respondents could perform satisfactorily in the plan to solve the problem. This implies that the respondents accurately follow their plan to solve the problems.

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Table 5. Level of Problem-solving Performance in Carrying out the Plan

Score	*f*	*%*	*Description*
8-10	22	64.71	Very Satisfactory
5-7	11	32.35	Satisfactory
2-4	1	2.94	Fair
0-1	0	0	Poor
Mean	**8.21**		**Very Satisfactory**

The result aligns with the claim of Osman et al. [3] that students who use problem-solving have higher thinking in various areas of their lives. Students learn analytical skills through problem-solving, including summarizing choices, identifying reasons, analyzing techniques or possibilities to address and resolve inconsistencies, and eventually putting the best plan into action.

3.2.4 Looking Back

As shown in Table 6, 16 (47.06%) respondents exhibited satisfactory performance after obtaining 5-7 scores on the test. Moreover, 15 (44.12%) performed satisfactorily in scoring 8-10, and one manifested fair performance after scoring 2-4. The meaning of 6.88 is interpreted as very satisfactory. This means that the student-respondents could correctly interpret their solving procedure according to what was being asked in the first place.

Table 6. Level of Problem-solving Performance in Looking-back at the Work

Score	*f*	*%*	*Description*
8-10	15	44.12	Very Satisfactory
5-7	16	47.06	Satisfactory
2-4	1	2.94	Fair
0-1	2	5.88	Poor
Mean	**6.88**		**Satisfactory**

Accordingly, Ulu [23] categorizes problem-solving approaches based on their level of comprehension. "Direct" solvers rush into equations and calculations, neglecting problem analysis and connections between givens and unknowns. In contrast, "comprehension-oriented" solvers meticulously record and analyze the problem text, ensuring their calculations are accurate and well-justified.

3.3. Relationship between the Critical Analysis and Performance in Trigonometry

Table 7 presents the correlation analysis results between the variables under study. As could be gleaned from the table, there is a significant relationship between the level of critical analysis in terms of mathematical translation and the student’s level of performance in Trigonometry in terms of understanding the problem (r = 0.58), devising a plan (r = 0.39), carrying out the plan (r = 0.54), and looking back (r = 0.65). Therefore, the null hypothesis is rejected. This implies that to solve mathematical problems successfully, and students should master translating word problems into mathematical symbols. This result parallels the findings of Ulu (2017), which state that students with high problem-solving success spend most of their time understanding and planning, while students with low problem-solving success spend most of their time doing their calculations.

Table 7. Relationship Between Critical Analysis and Performance in Trigonometry

IV Level of Critical Analysis	**DV Level of Performance in Trigonometry**			
	Understanding the Problem	Devising a Plan	Carrying out the Plan	Looking Back
Mathematical Translation	0.62**	0.39*	0.54**	0.65**
Identifying Appropriate Formula	0.43**	0.45**	0.38*	0.66**

** Significant at 0.05* *** significant at 0.01*

Meanwhile, there is a significant relationship between the level of critical analysis in terms of identifying appropriate formulas and the student's level of performance in Trigonometry in terms of understanding the problem (r = 0.43), devising a plan (r = 0.45), carrying out the plan (r = 0.38), and looking back (r = 0.66). Then, the null hypothesis is rejected. Identifying the appropriate formulas leads to successful problem-solving. The results are congruent with the findings of Huda et al. [32] that real-life mathematical applications require using well-thought strategies to solve mathematical problems. Novotna [38] concluded that computational education in a regular mathematics classroom may be promoted by addressing problem-solving techniques like analogy, guess-check revision, problem reformulation, solution drawing, systematic experimentation, way back, and use of graphs of functions. This was done given studies showing how these techniques can enhance mathematical problem-solving [1].

4. CONCLUSION

Based on the study's findings, the level of critical analysis in mathematical translation and identifying formulas was determined based on the respondents' understanding and experience with the subject matter. Also, the level of performance in trigonometry of students in understanding the problem, devising a plan, carrying out the plan, and looking back varies depending on the specific context and individual abilities. The students' problem-solving skills significantly affect their trigonometry performance by enabling them to understand trigonometry concepts and formulas accurately, think analytically, and approach complex problems creatively. Given the findings, it is recommended that teachers encourage students to improve their comprehension by familiarizing them with mathematical sentences and their corresponding mathematical expressions. Further, various problem-solving techniques should be taught to the students so they can choose the most suitable one for them. Problem-solving should be integrated into all mathematics subjects to enhance students' problem-solving performance. Problem-posing should also be encouraged.

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