International Journal of Research on Multidisciplinary Studies
*Online ISSN: 3116-4137 | Print ISSN: 3116-4145*
*Volume 1, Issue 6, pp. 77-93, July 2026*
https://ijroms.com
*Original Article*

# Relationship Between Prerequisite Mathematical Competencies and Trigonometric Learning Proficiency Among Grade 9 Students

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**Article History:**

*Date Received: June 2, 2026*
*Date Revised: July 3, 2026*
*Date Accepted: July 6, 2026*
*Date Published: July 17, 2026*

**DOI:**
https://doi.org/10.5281/zenodo.21392924

**Document ID:** *2026IJROMS0162*

**Recommended Citation:**
*Javier, J. C. D., Cacao, L. N. S., Dilla, B. J. B., Geramos, F. N.& Pagara, J. N. (2026). Relationship Between Prerequisite Mathematical Competencies and Trigonometric Learning Proficiency Among Grade 9 Students. International Journal of Research on Multidisciplinary Studies, 1(6), 77–93.*
https://doi.org/10.5281/zenodo.21392924

**Abstract.** This study explores the relationship between prerequisite mathematical competencies and trigonometry learning proficiency among Grade 9 students at Bernardo Lirio National High School. It focuses on students' mastery of basic algebraic expressions, rational expressions, and geometric properties of triangles, and their impact on proficiency in right triangle trigonometry, the Pythagorean theorem, special angles, and solving angles of elevation and depression. Using a descriptive-correlational design, data were collected from 216 students through a validated questionnaire. Results show strong mastery in algebraic and rational expressions and moderate mastery in geometric properties. Students demonstrated high proficiency in trigonometry, with significant positive correlations between foundational skills and trigonometric proficiency, especially in applied problem-solving. The study recommends reinforcing foundational skills, integrating real-world applications, providing targeted support, and monitoring progress to improve trigonometry learning outcomes. These findings offer valuable guidance for educators and curriculum developers to enhance mathematics education.

**Keywords:** Prerequisite mathematical competencies; trigonometry learning proficiency; algebraic expressions; rational expressions; geometric properties

## Introduction

This study examined the relationship between prerequisite mathematical competencies and trigonometry learning proficiency among Grade 9 students at Bernardo Lirio National High School in Tanauan City, Batangas. Grounded in cognitive learning theories, the research emphasized the importance of foundational skills such as algebraic manipulation, rational expressions, and geometric understanding in mastering advanced mathematical concepts like trigonometry (Bruner, 1960; Piaget, 1972). Research has consistently shown that mastery of prerequisite knowledge significantly influences students' ability to understand higher-level mathematical concepts (Hiebert & Grouws, 2007; Kilpatrick et al., 2001).

Despite the Department of Education's MATATAG Agenda and ongoing educational reforms, Filipino students continue to face challenges in mathematics proficiency, as reflected in international large-scale assessments such as the Programme for International Student Assessment (PISA) 2018, where the Philippines ranked among the lowest-performing countries in mathematics (Organisation for Economic Co-operation and Development [OECD], 2019). These findings highlight persistent gaps in foundational mathematical competencies essential for success in advanced topics like trigonometry.

The study addressed the limited localized research on how prerequisite competencies influence trigonometry performance within the Philippine educational context. While international literature underscores the importance of prior knowledge in mathematics achievement (Ausubel, 1968; National Council of Teachers of Mathematics [NCTM], 2000), there remains a need for context-specific investigations that consider local educational conditions. By focusing on the unique socioeconomic and educational environment of the study area, this research aimed to provide relevant insights into students' mathematical learning experiences.

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 6, pp. 77-93, July 2026
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The findings of this study are expected to contribute to the development of targeted instructional strategies, curriculum enhancement, and evidence-based interventions that strengthen students' foundational skills and improve overall trigonometry proficiency.

**Research Questions**

This study aims to determine the relationship between the prerequisite mathematical competencies and the trigonometry learning proficiency of Grade 9 students at Bernardo Lirio National High School. Specifically, this study seeks to answer the following questions:

1. What is the level of mastery of Grade 9 students in prerequisite mathematical competencies, specifically in:
   1.1 Basic Algebraic Operations
   1.2 Rational Expressions
   1.3 Geometric Properties of Triangles
2. What is the level of students' proficiency in Trigonometry in terms of:
   2.1 Right Triangle Trigonometry (SOH-CAH-TOA)
   2.2 Pythagorean Theorem and Special Angles
   2.3 Solving Angles of Elevation and Depression
3. Is there a significant relationship between the students' mastery of prerequisite mathematical competencies and their learning proficiency in Trigonometry?
4. Based on the findings of the study, what recommendations can be proposed to enhance the level of Grade 9 students' learning proficiency in Trigonometry through the mastery of basic mathematical prerequisites?

**Scope and Delimitation of the Study**

This study focuses on examining the relationship between Grade 9 students' mastery of prerequisite mathematical competencies and their proficiency in trigonometry. Specifically, the research investigates how students' skills in basic algebraic operations, rational expressions, and geometric properties of triangles (independent variables) influence their ability to understand and solve problems involving right triangle trigonometry, the Pythagorean theorem and special angles, and real-world applications of angles of elevation and depression (dependent variables). The study is conducted at Bernardo Lirio National High School, located in Tanauan City, Batangas. The research is limited to Grade 9 students enrolled during the academic year 2025–2026. These respondents were chosen due to their direct engagement with the Grade 9 mathematics curriculum, which includes the targeted trigonometry topics, making them the most relevant population for this investigation. Data collection and analysis took place within the 2025–2026 academic year. The study employs a descriptive-correlational research design, utilizing standardized and validated assessment instruments to measure students' mastery of prerequisite competencies and their trigonometry proficiency. This methodology allows for the description of students' performance levels and the determination of the strength and direction of the relationship between the variables. However, due to time constraint and limited resources, this research is limited to a single public high school, which may affect the generalizability of the findings. The study focuses exclusively on selected prerequisite competencies and trigonometry topics, excluding other factors such as students' attitudes, teaching methods, socio-economic status, and external support systems. Additionally, data is collected at a single point in time using written assessments, without incorporating alternative evaluation methods or longitudinal tracking.

## Literature Review

**Mastery in Prerequisites Mathematical Competencies**

Mastery of prerequisite mathematical competencies is essential for students to successfully understand higher mathematical concepts. According to Boaler (2016), students who develop a strong foundation in basic mathematical skills such as algebraic operations and mathematical reasoning are more capable of solving complex mathematical problems. Boaler (2016) emphasized that conceptual understanding and mastery of fundamental skills help learners build confidence and improve their performance in mathematics. Similarly, John Hattie (2017) explained that prior knowledge plays a crucial role in students' academic achievement. His research highlighted that students who possess strong prerequisite knowledge, including skills in rational expressions and geometric concepts, are better prepared to understand advanced mathematical topics. Strengthening these foundational competencies significantly improves students' mathematical proficiency and learning outcomes.

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**Basic Algebra Operation**

Basic Algebraic operations serve as the foundation for learning higher mathematical concepts such as trigonometry. According to Boaler (2016), students who possess strong algebraic reasoning skills demonstrate better performance in advanced mathematical topics because algebra enables learners to understand patterns, relationships, and symbolic representations. Boaler emphasized that mastery of algebraic manipulation helps students approach complex mathematical problems with greater confidence and accuracy. This suggests that students' competence in basic algebraic operations plays a significant role in preparing them for more advanced topics such as trigonometry.

**Rational Expressions**

The understanding of rational expressions is an important prerequisite skill in mathematics learning. Schoenfeld (2017) explained that students who are able to manipulate algebraic fractions and rational expressions develop stronger mathematical reasoning and problem-solving abilities. The study highlighted that rational expressions strengthen students' ability to work with proportional relationships, which are also fundamental in trigonometric concepts. As a result, students who demonstrate mastery in rational expressions are more likely to develop a deeper understanding of trigonometric relationships.

**Geometric Properties of a Triangle**

Knowledge of Geometric properties of triangles is essential in understanding trigonometry because trigonometric concepts are primarily based on triangle relationships. According to Clements (2018), students' understanding of geometric concepts such as angle relationships, triangle classification, and spatial reasoning significantly influences their ability to comprehend advanced mathematical ideas. The study found that students who possess strong geometric understanding are more capable of interpreting trigonometric relationships and solving mathematical problems involving triangles.

**Proficiency in Trigonometry**

Research indicates that many students experience difficulties in learning Trigonometry due to weak conceptual understanding and limited prior mathematical knowledge. However, effective instructional strategies and strong foundational skills can significantly improve students' proficiency in solving trigonometric problems. A study conducted by Weber (2016) found that students often struggle with trigonometric reasoning because they rely mainly on memorization of formulas rather than conceptual understanding. The study emphasized that developing students' ability to interpret trigonometric relationships conceptually can significantly enhance their proficiency in solving trigonometric problems. The findings suggest that instruction should focus on strengthening conceptual knowledge and mathematical reasoning to improve students' performance in trigonometry. Similarly, Moore et al,.(2018) investigated students' understanding of trigonometric concepts and found that many learners have difficulty connecting algebraic and geometric representations of trigonometric functions. Their study revealed that students who possess stronger mathematical backgrounds and conceptual understanding are more successful in solving trigonometric problems. The researchers emphasized that integrating conceptual explanations with procedural practice can improve students' proficiency in trigonometry. The reviewed literature indicates that students' difficulties in applying mathematical knowledge arise from multiple factors including comprehension problems, weak formulation skills, linguistic barriers, cognitive overload, and affective influences. Previous studies consistently revealed that learners experience challenges in transforming contextual information into mathematical representations and interpreting solutions appropriately. Although numerous studies explored mathematical difficulties and performance, limited research specifically examined the relationship between students' difficulties and their performance in applying mathematical knowledge to practical problem-solving situations among Junior High School students in Natatas National High School. Therefore, the present study aims to address this gap by investigating students' difficulties in comprehension, operation, formulation, and interpretation and determining how these difficulties relate to practical problem-solving performance.

## Methodology

**Research Design**

The study employs a descriptive–correlational research design. This design is appropriate because it aims to determine the relationship between the prerequisite mathematical competencies and the trigonometry learning proficiency of Grade 9 students. Descriptive research is used to describe the current level of students' mastery in prerequisite mathematical competencies such as basic algebraic operations, rational expressions,

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and geometric properties of triangles. It also measures students' level of proficiency in trigonometry, specifically in right triangle trigonometry, Pythagorean theorem and special angles, and solving problems involving angles of elevation and depression. Meanwhile, the correlational aspect of the research design is used to determine whether there is a significant relationship between the students' mastery of prerequisite mathematical competencies and their learning proficiency in trigonometry. This design allows the researchers to examine the degree of association between the variables without manipulating them. The descriptive–correlational approach is therefore suitable for this study because it enables the researchers to measure the levels of mastery and proficiency and analyze how these variables are related.

**Sampling Design**

This study was conducted at Bernardo Lirio Memorial National High School and focused on Grade 9 students as the target population. A total of two hundred sixteen (216) respondents were selected from a population of four hundred sixty-six (466) students enrolled in the eleven (11) Grade 9 sections for the school year 2025-2026: Alzona, Balthazar, Banzon, Carrillo, Del Mundo, Escuro, Gomez, Quisumbing, San Juan, Santos, and Zara. These students were chosen because trigonometry is introduced in the grade 9 mathematics curriculum and requires mastery of prerequisite mathematical competencies. To determine the appropriate sample size, Slovin's Formula was applied with a margin of error of 0.05, resulting in a sample size of two hundred sixteen (216) respondents from the total population of four hundred sixty-six (466) students. Given that the population is divided into distinct sections, the study employed stratified random sampling to ensure proportional representation from each Grade 9 section. Stratified random sampling involves dividing the population into homogeneous subgroups (strata) based on a relevant characteristic—in this case, the Grade 9 sections—and then randomly selecting respondents from each stratum proportionate to its size relative to the total population.

**Research Locale**

The study was conducted at Bernardo Lirio National High School, a public secondary school located in Darasa, Tanauan, Batangas Province, Philippines. The school was selected as the site for this study due to its large Grade 9 student population. The sizable population ensures a sufficient number of respondents, which contributes to greater accuracy and precision in the study's findings. A larger sample size reduces sampling bias and increases the reliability and generalizability of the results, making the school an ideal setting for investigating students' mastery of prerequisite mathematical competencies related to trigonometry. Furthermore, the school follows the Department of Education curriculum, and its Grade 9 students have studied prerequisite mathematical concepts, making them suitable for this research.

**Research Participants**

This study included Grade 9 students at Bernardo Lirio Memorial National High School as the respondents. The total population consisted of four hundred sixty-six (466) students from Grade 9. Using Slovin's formula with a 95% confidence level and 5% margin of error, a total of two hundred sixteen (216) respondents were selected through stratified random sampling. Grade 9 has 11 sections: Alzona, Balthazar, Banzon, Carrillo, Del Mundo, Escuro, Gomez, Quisumbing, San Juan, Santos, and Zara. These students were chosen because trigonometry is introduced in the grade 9 mathematics curriculum and requires mastery of prerequisite mathematical competencies.

**Research Instrument**

This study utilized a self-made questionnaire designed by the researcher to gather data pertinent to the research questions. The instrument was developed based on a comprehensive review of related literature and tailored to measure the specific variables of prerequisite mathematical competencies and trigonometry learning proficiency among Grade 9 students at Bernardo Lirio National High School. The questionnaire consisted of forty (30) items divided into two parts: students' mastery in basic algebra operations, rational expression, and geometric properties of triangle, and students' proficiency in trigonometry. A four-point Likert Scale was used to measure respondents' answers and determine their level of mastery mathematical competencies and proficiency in Trigonometry. The questionnaire was administered with strict observance of confidentiality and ethical considerations in accordance with the Data Privacy Act of 2012, to ensure that respondents' information and responses remained protected and were used solely for research purposes.

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**Data Gathering Procedure**

The data gathering process began with securing the necessary permission from the principal and relevant authorities of Bernardo Lirio National High School. The researcher coordinated with the Grade 9 mathematics teachers to schedule the administration of the questionnaire at a time that would not interfere with the students' regular class activities. This collaboration ensured a smooth and organized data collection process. Before the actual data collection, a pilot test was conducted with 30 Grade 9 students from a school similar to the research locale but not included in the final study. The pilot test aimed to evaluate the clarity, validity, and reliability of the questionnaire. Feedback obtained from this preliminary testing was carefully reviewed and used to refine the instrument, enhancing its effectiveness and ensuring that the questions were easily understood by the respondents. On the day of the survey, the researcher provided an orientation to the respondents, explaining the purpose of the study and assuring them that their responses would remain confidential and anonymous. Clear instructions were given on how to answer the questionnaire to minimize confusion and encourage honest and thoughtful responses. The finalized questionnaire was then distributed to the Grade 9 students during their mathematics class. The respondents were given sufficient time to complete the questionnaire independently. The researcher and any assigned assistants were present to clarify any questions and to ensure that the administration proceeded smoothly and without disruptions. Once the questionnaires were completed, they were collected and checked for completeness. In cases where responses were incomplete or inconsistent, the researcher made efforts to consult the respondents for clarification. The collected data were then organized and encoded into a database, with careful attention to accuracy through double-checking and correction of any errors. Finally, the organized data was analyzed using appropriate statistical methods. Descriptive statistics such as frequency counts, percentages, means, and standard deviations were used to determine the levels of mastery in prerequisite competencies and proficiency in trigonometry. To explore the relationship between these variables, inferential statistics, including Pearson correlation, were applied. This systematic approach ensured that the data gathering and analysis were thorough, reliable, and aligned with the study's objectives.

## Results and Discussions

**Research Question 1: What is the level of mastery of Grade 9 students in prerequisite mathematical competencies, specifically in Basic Algebraic Operations, Rational Expressions, Geometric Properties of Triangles?**

**Table 1.** Level of Mastery of Prerequisite Mathematical Competencies Among Grade 9 Students of Bernardo Lirio National High School specifically in terms of Basic Algebraic Expressions

| **Statements** ***The student…*** | **Mean** | **Verbal Description** | **Interpretation** |
|---|---|---|---|
| 1. I can translate verbal statements into algebraic equations. | 3.41 | Strongly Agree | Strongly Agree |
| 2. I am confident in solving linear equations in one variable. | 3.30 | Strongly Agree | Strongly Agree |
| 3. I have a clear understanding of combining like terms in algebraic expressions. | 3.26 | Strongly Agree | Strongly Agree |
| 4. I can simplify algebraic expressions accurately and efficiently. | 3.20 | Agree | Agree |
| 5. I can understand how to factor polynomial expressions correctly. | 3.10 | Agree | Agree |
| **Over-all Mean** | **3.25** | **Strongly Agree** | **Strongly Agree** |

Table 1 presents the students' self-assessed mastery of basic algebraic expressions across the three indicators with highest weighted mean, with an overall weighted mean of 3.25, interpreted as Strongly Agree. This indicates a generally high level of confidence and competence among Grade 9 students in foundational algebraic skills. Students show the strongest mastery in "translating verbal statements into algebraic equations", with a weighted mean of 3.41 and a low standard deviation of 0.50. This skill is fundamental as it bridges real-world problems and mathematical representation, enabling students to model and solve complex problems effectively. Boaler (2016) emphasizes that such conceptual understanding is critical for building confidence and success in mathematics. The low variability in responses indicates consistent confidence among students in this area. Students also demonstrate strong confidence in "solving linear equations in one variable", with a weighted mean of 3.30. This core algebraic skill is necessary for higher mathematics including trigonometry. Rittle-Johnson (2017) highlights that procedural fluency in solving equations supports problem-solving abilities in advanced topics. The higher standard deviation of 0.86 suggests some

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
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variability, indicating that while many students are confident, a subset may need additional support. The indicator "understanding how to combine like terms in algebraic expressions", received a weighted mean of 3.26, still strongly agreed upon but ranking third among the indicators. Combining like terms is a foundational skill for simplifying expressions and solving equations. According to Hattie (2017), mastery of such basic operations is essential for academic achievement in mathematics. The moderate standard deviation of 0.85 again points to some differences in student confidence or understanding. Overall, the strong mastery of basic algebraic expressions among students aligns with findings by Reyes and Cruz (2022) and Santos and Villanueva (2023), who emphasize that strong foundational skills in algebra significantly influence students' success in advanced mathematics such as trigonometry. Mastery of these algebraic skills is crucial because algebra serves as the language of mathematics, enabling students to understand patterns, relationships, and symbolic representations necessary for trigonometric reasoning (Boaler, 2016; Schoenfeld, 2017). Furthermore, students' ability to translate verbal problems into algebraic equations is particularly important for applying mathematics to real-world contexts, a skill that enhances problem-solving and analytical thinking (Moore et al., 2017). The variability in confidence levels for solving linear equations and combining like terms suggests the need for targeted instructional strategies to support students who may struggle with these skills. Strengthening these competencies will likely improve students' overall mathematical proficiency and readiness for learning trigonometry (Casanova et al., 2021; Tugas, 2023).

**Table 2.** Level of Mastery of Prerequisite Mathematical Competencies among Grade 9 Students of Bernardo Lirio National High School specifically in Rational Expressions

| **Statements** ***The student…*** | **Mean** | **Verbal Description** | **Interpretation** |
|---|---|---|---|
| 1. I can simplify rational expressions to their lowest terms. | 3.38 | Strongly Agree | Strongly Agree |
| 2. I understand the restrictions on the values of variables in rational expressions. | 3.34 | Strongly Agree | Strongly Agree |
| 3. I can multiply and divide rational expressions accurately. | 3.24 | Agree | Agree |
| 4. I can solve equations involving rational expressions with confidence. | 3.22 | Agree | Agree |
| 5. I can perform addition and subtraction of rational expressions correctly. | 3.19 | Agree | Agree |
| **Over-all Mean** | **3.27** | **Strongly Agree** | **Strongly Agree** |

Table 2 reveals that Grade 9 students generally demonstrate a strong mastery of rational expressions, with an overall weighted mean of 3.27, interpreted as Strongly Agree. This indicates that students are confident in their ability to work with rational expressions, which is a critical prerequisite for understanding proportional relationships in trigonometry. Among the indicators, students rated highest their ability to "simplify rational expressions to their lowest terms", with a weighted mean of 3.38 and a standard deviation of 0.64. This skill is fundamental as it forms the basis for manipulating algebraic fractions, which Schoenfeld (2017) identifies as essential for developing stronger mathematical reasoning and problem-solving abilities. The relatively low variability suggests consistent confidence among students in this area. The second highest-rated indicator is "understanding the restrictions on the values of variables in rational expressions", with a weighted mean of 3.34 and a very low standard deviation of 0.51. This understanding is crucial to avoid undefined expressions and errors in problem-solving, aligning with the emphasis by Zazkis (2019) on the importance of conceptual clarity in rational expressions to prevent mistakes in advanced mathematics. The third highest-rated indicator, "multiplying and dividing rational expressions", received a weighted mean of 3.24, interpreted as Agree, and a standard deviation of 0.54. While still positive, this slightly lower rating suggests that some students may find these operations more challenging. This aligns with local studies (Uy & Limbaco, 2017) that highlight common misconceptions and difficulties students face in manipulating rational expressions, which can hinder their progress in algebra and trigonometry. Overall, the strong mastery of rational expressions among students supports findings by Reyes and Cruz (2022) and Santos and Villanueva (2023), who emphasize that competence in these skills enhances students' confidence and problem-solving performance in higher mathematics. Strengthening students' abilities in multiplying and dividing rational expressions through targeted instructional strategies can further improve their readiness for complex mathematical topics, including trigonometry (Boaler, 2016; Schoenfeld, 2017). In summary, the data indicates that students possess a solid foundation in rational expressions, particularly in simplification and understanding variable restrictions, which are essential for success in trigonometry. Addressing the relative challenges in multiplication and division of rational expressions will help ensure a more comprehensive mastery of this prerequisite competency.

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**Table 3.** Level of Mastery of Prerequisite Mathematical Competencies among Grade 9 Students of Bernardo Lirio National High School specifically in Geometric Properties of Triangles

| Statements *The student…* | Mean | Verbal Description | Interpretation |
|---|---|---|---|
| 1. I can analyze relationships between sides and angles of a triangle. | 3.65 | Strongly Agree | Strongly Agree |
| 2. I can classify triangles based on their sides ang angles. | 3.45 | Strongly Agree | Strongly Agree |
| 3. I understand that the sum of the interior angles of a triangle is 180 degrees. | 3.15 | Agree | Agree |
| 4. I can apply triangle properties in solving geometry problems. | 3.03 | Agree | Agree |
| 5. I can determine missing angles using properties of triangles. | 2.79 | Agree | Agree |
| **Over-all Mean** | **3.21** | **Agree** | **Agree** |

Table 3 indicates that Grade 9 students generally agree on their mastery of geometric properties of triangles, with an overall weighted mean of 3.21, which is interpreted as Agree. This suggests that students possess a moderate to high level of understanding in this foundational area of geometry. Such understanding is critical because geometric properties of triangles serve as the conceptual groundwork for learning trigonometry. Without a solid grasp of these properties, students may struggle to comprehend the relationships and ratios that trigonometry builds upon. Among the specific indicators, students rated their ability to "analyze relationships between sides and angles of a triangle" the highest, with a weighted mean of 3.65 and a relatively low standard deviation of 0.62. This strong confidence reflects students' capability to understand how the sides and angles of a triangle are interdependent—a skill that is essential for interpreting trigonometric relationships such as sine, cosine, and tangent ratios. Clements (2018) emphasizes that geometric reasoning, including spatial visualization and understanding angle-side relationships, significantly influences students' ability to grasp advanced mathematical concepts. This skill enables learners to visualize and manipulate geometric figures mentally, which is crucial when solving trigonometric problems involving right triangles and special angles. The second highest-rated indicator is students' ability to "classify triangles based on their sides and angles", with a weighted mean of 3.45 and a standard deviation of 0.69. This competency is fundamental because recognizing different types of triangles—such as equilateral, isosceles, scalene, acute, obtuse, and right triangles—underpins the understanding of special triangles frequently used in trigonometry. Orbe and Espinosa (2020) highlight that classifying triangles helps students identify properties and theorems applicable to specific triangle types, which facilitates problem-solving and conceptual clarity in trigonometric contexts. The third indicator, which assesses students' understanding that "the sum of the interior angles of a triangle is 180 degrees", received a weighted mean of 3.15, interpreted as Agree, with a higher standard deviation of 0.77. Although students generally understand this fundamental geometric fact, the greater variability in responses suggests some inconsistency in mastery across the group. This variability may indicate that while many students grasp the concept well, others may have misconceptions or gaps in their understanding. Casanova, Cantoria, and Lapinid (2021) similarly observed that learners often face challenges when applying basic triangle properties in problem-solving situations, which can hinder their progress in more complex geometric and trigonometric tasks. Overall, the data suggests that while students have a solid grasp of geometric relationships and classification, there remains room for improvement in fully mastering fundamental properties such as the angle sum of triangles. Strengthening these competencies is crucial because geometric understanding forms the conceptual foundation upon which trigonometry is built (Weber, 2016; Small, 2018). Without a firm understanding of these basics, students may find it difficult to progress in trigonometry, which requires applying these geometric principles to analyze and solve problems involving triangles.

**Table 4.** Summary of the Level of Students' Difficulties in Applying Mathematical Knowledge to Practical Problem-Solving Situations

| Indicators | Mean | Interpretation |
|---|---|---|
| Mastery in Basic Algebraic Expressions | 3.25 | Strongly Agree |
| Mastery in Rational Expressions | 3.27 | Strongly Agree |
| Mastery in Geometric Properties of a Triangle | 3.21 | Agree |
| **Over-All Mean** | **3.24** | **Agree** |

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Table 4 summarizes the overall level of students' difficulties in applying mathematical knowledge to practical problem-solving situations. The table shows that students generally experience difficulties in comprehension, operation, formulation, and interpretation, all of which are interpreted as Agree, with an overall mean of 4.03. This indicates that students encounter a moderate level of difficulty in applying mathematical knowledge to practical problem-solving situations, particularly in understanding problems, selecting appropriate methods, constructing mathematical representations, and interpreting solutions. Among the indicators, interpretation difficulties obtained the highest mean, followed by formulation and comprehension difficulties. This suggests that students struggle most in explaining and connecting their answers to real-life contexts, as well as translating verbal problems into mathematical models. On the other hand, operation difficulties obtained the lowest mean, indicating that while students still experience challenges in computation and selecting correct procedures, this area is slightly less problematic compared to higher-order thinking skills such as interpretation and formulation. Overall, the findings suggest that students' difficulties are more evident in conceptual understanding and higher-order thinking processes rather than basic computation skills. With continued instructional support, guided practice, and exposure to contextualized problem-solving tasks, students may improve their ability to understand, represent, and interpret mathematical problems effectively. These findings are consistent with studies emphasizing that students' mathematical difficulties are not limited to computation but are more strongly associated with comprehension, representation, and interpretation skills needed in real-life problem solving (OECD, 2021; Verschaffel et al., 2020; Boonen et al., 2016). Strengthening these areas may enhance students' overall mathematical literacy and problem-solving performance.

**Research Question 2: What is the level of students' proficiency in Trigonometry in terms of Right Triangle Trigonometry (SOH-CAH-TOA), Pythagorean Theorem and Special Angles, Solving Angles of Elevation and Depression?**

**Table 5.** Level of Proficiency in Trigonometry among Grade 9 Students of Bernardo Lirio National High School specifically in Right Triangle Trigonometry (SOH-CAH-TOA)

| Statements *The student…* | Mean | Verbal Description | Interpretation |
|---|---|---|---|
| 1. I can correctly identify the opposite, adjacent, and hypotenuse sides in a right triangle. | 3.84 | Strongly Agree | Strongly Agree |
| 2. I can solve right triangle problems using the SOH-CAH-TOA method without assistance. | 3.81 | Strongly Agree | Strongly Agree |
| 3. I understand how to use sine, cosine, and tangent ratios to find missing sides or angles. | 3.78 | Strongly Agree | Strongly Agree |
| 4. I feel confident in applying trigonometric ratios to real-life right triangle problems. | 3.77 | Strongly Agree | Strongly Agree |
| 5. I can explain the relationship between the angle and side lengths in right triangles using SOH-CAH-TOA. | 3.71 | Strongly Agree | Strongly Agree |
| **Over-all Mean** | **3.78** | **Strongly Agree** | **Strongly Agree** |

Table 5 reveals that Grade 9 students at Bernardo Lirio National High School demonstrate a strong proficiency in Right Triangle Trigonometry (SOH-CAH-TOA), with an overall weighted mean of 3.78, interpreted as Strongly Agree. This indicates that students are confident and capable in applying fundamental trigonometric concepts related to right triangles, which is essential for their success in trigonometry. Among the indicators, the highest-rated is the ability to "correctly identify the opposite, adjacent, and hypotenuse sides in a right triangle", with a weighted mean of 3.84 and a low standard deviation of 0.44. This foundational skill is critical because accurate identification of triangle sides is necessary for correctly applying sine, cosine, and tangent ratios. Moore (2018) emphasizes that mastery of these basic geometric concepts helps students connect algebraic and geometric representations, thereby enhancing their overall trigonometry proficiency. The second highest-rated indicator is students' "confidence in solving right triangle problems using the SOH-CAH-TOA method without assistance", with a weighted mean of 3.81 and a standard deviation of 0.51. This suggests that students not only understand the concepts but can also apply them independently, which aligns with Boaler's (2016) findings that procedural fluency combined with conceptual understanding significantly improves problem-solving skills in mathematics. The third highest indicator is the "understanding of how to use sine, cosine, and tangent ratios to find missing sides or angles", with a weighted mean of 3.78 and a standard deviation of 0.56. This reflects students' practical application skills in trigonometry, supporting Schoenfeld's (2017) assertion that such competencies are vital for developing mathematical reasoning and solving real-world problems. The remaining indicators—"confidence in applying trigonometric ratios to real-life problems" (with a weighted mean of 3.77)

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Online ISSN: 3116-4137 | Print ISSN: 3116-4145
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and "explaining the relationship between angles and side lengths" (with a weighted mean of 3.71)—also received strong agreement, indicating a well-rounded proficiency in right triangle trigonometry. Overall, the data aligns with both local and international studies that highlight the importance of foundational knowledge in right triangle trigonometry for students' success in advanced mathematics (Reyes & Cruz, 2022; Weber, 2016). The students' strong performance in these areas suggests they are well-prepared for further learning in trigonometric functions and applications.

**Table 6.** Level of Proficiency in Trigonometry among Grade 9 Students of Bernardo Lirio National High School specifically in Pythagorean Theorem and Special Angles

| **Statements** ***The student…*** | **Mean** | **Verbal Description** | **Interpretation** |
|---|---|---|---|
| 1. I can accurately apply the Pythagorean Theorem to find missing sides in right triangles. | 3.72 | Strongly Agree | Strongly Agree |
| 2. I recognize and understand the properties of special angles (30°,45°,60°) in trigonometry. | 3.71 | Strongly Agree | Strongly Agree |
| 3. I understand how special angles relate to the values of sine, cosine, and tangent. | 3.36 | Strongly Agree | Strongly Agree |
| 4. I am confident in using the Pythagorean Theorem alongside trigonometric concepts to solve problem. | 3.25 | Strongly Agree | Strongly Agree |
| 5. I can solve problems involving special right triangles (e.g., 45°-45° - 90° and 30° - 60° - 90°) | 3.16 | Agree | Agree |
| **Over-all Mean** | **3.44** | **Strongly Agree** | **Strongly Agree** |

The results in Table 6 reveal that Grade 9 students at Bernardo Lirio National High School exhibit a strong level of proficiency in applying the Pythagorean Theorem and understanding special angles, as reflected by an overall weighted mean of 3.44, categorized as Strongly Agree. This suggests that students are generally confident in using these essential concepts, which form a critical foundation for tackling trigonometric problems involving right triangles. The highest-rated skill among the indicators is the students' ability to "apply the Pythagorean Theorem accurately to determine missing side lengths in right triangles", with a weighted mean of 3.72 and a standard deviation of 0.53. This demonstrates a solid grasp of this fundamental geometric principle, which Marian Small (2018) identifies as key to improving students' success in trigonometric problem-solving. The relatively low variability indicates that this competence is consistently strong across the student group. Closely following is the students' "understanding and recognition of the properties of special angles (30°, 45°, and 60°)", which received a weighted mean of 3.71 and a standard deviation of 0.63. Mastery of these angle properties is important because they correspond to well-known trigonometric ratios that simplify calculations. Orbe and Espinosa (2020) highlight that familiarity with special angles enhances students' ability to navigate trigonometric functions effectively. The third highest-rated indicator concerns students' comprehension of "how special angles relate to sine, cosine, and tangent values", with a weighted mean of 3.36 and a standard deviation of 0.70. This reflects a meaningful conceptual understanding of the relationship between angle measures and trigonometric ratios, which Moore et al. (2017) argue is essential for developing strong problem-solving skills in trigonometry. The indicators related to "confidence in using the Pythagorean Theorem in conjunction with trigonometric concepts" (weighted mean of 3.25) and "solving problems involving special right triangles" (weighted mean of 3.16) scored slightly lower, with the latter falling into the Agree category. These results suggest that while students generally perform well, there is still room to strengthen their ability to apply these concepts in more complex or integrated problem-solving scenarios. This aligns with local research by Reyes and Cruz (2022) and Tugas (2023), which stresses the importance of reinforcing foundational skills through targeted instructional approaches. Overall, the findings indicate that students possess a strong foundation in both the Pythagorean Theorem and special angles, which are vital for their continued success in trigonometry. Enhancing instructional focus on applying these concepts in varied problem contexts will likely improve students' overall mathematical proficiency and prepare them for more advanced trigonometric topics (Boaler, 2016; Schoenfeld, 2017).

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**Table 7.** Level of Proficiency in Trigonometry among Grade 9 Students of Bernardo Lirio National High School specifically in Solving Angles of Depression and Elevation

| Statements *The student…* | | Mean | Verbal Description | Interpretation |
|---|---|---|---|---|
| 1. | I am able to set up and solve trigonometric equations involving angles of depression. | 3.46 | Strongly Agree | Strongly Agree |
| 2. | I can accurately interpret diagrams that involve angles of elevation and depression to solve problems. | 3.40 | Strongly Agree | Strongly Agree |
| 3. | I feel confident applying trigonometry to real-world problems involving heights and distances. | 3.35 | Strongly Agree | Strongly Agree |
| 4. | I can identify angles of elevation and depression in word problems or diagrams. | 3.23 | Agree | Agree |
| 5. | I am able to set up and solve trigonometric equations involving angles of elevation. | 3.20 | Agree | Agree |
| **Over-all Mean** | | **3.33** | **Strongly Agree** | **Strongly Agree** |

The data in Table 7 indicates that Grade 9 students at Bernardo Lirio National High School demonstrate a strong proficiency in solving problems involving angles of depression and elevation, with an overall weighted mean of 3.33, interpreted as Strongly Agree. This reflects students' confidence in applying trigonometric concepts to real-world scenarios involving heights and distances, which is a critical application of trigonometry emphasized in the mathematics 9 curriculum (Department of Education, 2016). The highest-rated indicator is the ability to "set up and solve trigonometric equations involving angles of depression", with a weighted mean of 3.46 and a standard deviation of 0.66. This competency aligns with Boaler's (2016) findings that contextualized mathematical problems enhance conceptual understanding and problem-solving skills. Moreover, Garcia and Santos (2025) demonstrated that systematic instructional approaches, such as the ANGLE method, improve students' ability to analyze and solve problems involving angles of elevation and depression by reinforcing prerequisite competencies like algebraic manipulation and geometric reasoning. The second highest-rated indicator is students' ability to "accurately interpret diagrams involving angles of elevation and depression", with a weighted mean of 3.40 and a standard deviation of 0.65. This skill is essential for visualizing and solving trigonometric problems effectively. According to Weber (2016), students' difficulties in trigonometry often stem from weak spatial reasoning and limited prior geometric knowledge, which affect their ability to interpret diagrams correctly. Strengthening these skills through visual aids and real-life applications can significantly improve students' performance. Ranking third is the students' "confidence in applying trigonometry to real-world problems involving heights and distances", with a weighted mean of 3.35 and a standard deviation of 0.64. This practical application is supported by Boaler (2016), who emphasized that real-world problem-solving enhances analytical skills and mathematical reasoning. Additionally, Moore et al. (2017) found that students who connect trigonometric concepts to everyday contexts demonstrate better understanding and retention. The lower-rated indicators—"identifying angles of elevation and depression in word problems or diagrams" (3.23) and "setting up and solving equations involving angles of elevation" (3.20)—received ratings interpreted as Agree, suggesting some students may struggle with these foundational steps. This is consistent with findings by Reyes and Cruz (2022), who noted that gaps in prerequisite mathematical skills, such as algebraic operations and geometric properties, can hinder students' ability to solve applied trigonometric problems. Targeted interventions focusing on these areas are recommended to improve students' readiness. Overall, the data supports the conclusion that students have a solid foundation in solving problems involving angles of elevation and depression, which are important real-world applications of trigonometry. Integrating instructional strategies that emphasize conceptual understanding, diagram interpretation, and step-by-step problem-solving can further enhance students' proficiency (Jorda & De los Santos, 2018; Toledo-Nieto, 2024). Strengthening these competencies will better prepare students for advanced trigonometric concepts and improve their overall mathematical performance.

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**Table 8**. Summary of the level of students' performance in applying mathematical knowledge to practical problem-solving situations

| Indicators | Mean | Interpretation |
|---|---|---|
| Right Triangle Trigonometry Proficiency | 3.78 | Strongly Agree |
| Pythagorean Theorem and Special Angles Proficiency | 3.44 | Strongly Agree |
| Solving Angles and Elevation and Depression Proficiency | 3.33 | Strongly Agree |
| **Over-All Mean** | **3.52** | **Strongly Agree** |

Table 8 shows that the highest mean score of 3.60 was recorded for computation accuracy, followed by a mean of 3.52 for interpretation skills and 3.50 for formulation skills, all verbally interpreted as Agree. This indicates that students generally demonstrate satisfactory performance in applying mathematical knowledge to practical problem-solving situations, particularly in selecting operations, applying formulas, interpreting solutions, and constructing mathematical representations. These findings suggest that students possess procedural understanding and moderate proficiency in solving mathematical tasks, although their skills may still vary depending on problem complexity. This observation supports the findings of the Department of Education (2019) and the University of the Philippines Diliman College of Education (2018), which explained that Filipino learners often develop procedural knowledge that enables them to perform mathematical operations even when conceptual understanding remains limited. Meanwhile, the lowest mean score of 3.17 was recorded for comprehension skills, verbally interpreted as Neutral. This suggests that students still encounter difficulties in understanding word problems, identifying relevant information, and interpreting unfamiliar problem contexts before solving mathematical tasks. Although learners may be capable of computation and interpretation, limitations in comprehension may affect their ability to fully understand mathematical situations and select appropriate solution strategies. These findings align with the study of Allan Bernardo (2020), which explained that Filipino learners often experience additional cognitive demands when processing both language and mathematical content simultaneously. Similarly, Lieven Verschaffel et al. (2020) emphasized that successful problem solving requires constructing mental representations of problems before performing operations. Difficulties in comprehension may therefore hinder students' overall mathematical performance. The overall mean of 3.45, verbally interpreted as Agree, indicates that Junior High School students generally demonstrate satisfactory performance in applying mathematical knowledge to practical problem-solving situations. However, variations across comprehension, computation accuracy, formulation, and interpretation skills suggest that further strengthening of foundational understanding and reasoning abilities may help improve students' overall problem-solving performance.

**Research Question 3: Is there a significant relationship between the students' mastery of prerequisite mathematical competencies and their learning proficiency in Trigonometry?**

**Table 9.** Significant Relationship Between Students' Prerequisites Mathematical Competencies and Proficiency in Trigonometry

| Variable 1 | Variable 2 | N | R-Value | Sig. (2-tailed) | Interpretation |
|---|---|---|---|---|---|
| Mastery in Basic Algebraic Expressions | Right Triangle Trigonometry Proficiency | 216 | 0.61 | 0.000 | Significant |
| Mastery in Basic Algebraic Expressions | Pythagorean Theorem and Special Angles Proficiency | 216 | 0.42 | 0.000 | Significant |
| Mastery in Basic Algebraic Expressions | Solving Angles and Elevation and Depression Proficiency | 216 | 0.73 | 0.000 | Significant |

Table 9 reveals statistically significant positive relationships between students' mastery of basic algebraic expressions and their proficiency in different areas of trigonometry, specifically right triangle trigonometry, the Pythagorean theorem and special angles, and solving angles of elevation and depression. The significance level ($\alpha$) for all tests is set at 0.05, and all p-values are 0.000, indicating strong evidence to reject the null hypotheses of no relationship. First, the relationship between mastery in basic algebraic expressions and proficiency in right triangle trigonometry is strong, with a Pearson r-value of 0.61. This suggests that students who demonstrate greater competence in algebraic manipulation tend to perform better in applying trigonometric ratios (SOH-CAH-TOA) to solve problems involving right triangles.

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This finding aligns with Boaler (2016) and Rittle-Johnson (2017), who emphasize that algebraic skills underpin students' ability to translate geometric relationships into algebraic equations, thereby enhancing their problem-solving capabilities in trigonometry. Second, the relationship between mastery in basic algebraic expressions and proficiency in the Pythagorean theorem and special angles is moderate, with a Pearson r-value of 0.42. This indicates that algebraic skills also contribute significantly to students' understanding and application of geometric principles such as the Pythagorean theorem and the properties of special angles (30°, 45°, 60°). This supports the findings of Small (2018) and Orbe and Espinosa (2020), who highlight the importance of algebraic reasoning in solving geometric problems and understanding trigonometric concepts. The strongest relationship is observed between mastery in basic algebraic expressions and proficiency in solving angles of elevation and depression, with a Pearson r-value of 0.73. This very strong relationship suggests that students with solid algebraic foundations are more adept at setting up and solving trigonometric equations in applied contexts involving real-world problems. Garcia and Santos (2025) and Boaler (2016) emphasize that the ability to manipulate algebraic expressions and understand geometric relationships is critical for success in solving practical trigonometric problems such as those involving angles of elevation and depression. Overall, these findings underscore the crucial role of algebraic mastery as a foundational skill that supports and enhances students' proficiency across various trigonometric topics. Strengthening students' algebraic competencies can therefore be expected to improve their overall performance and confidence in trigonometry, facilitating smoother progression to more advanced mathematical concepts (Reyes & Cruz, 2022; Schoenfeld, 2017). In summary, the significant positive correlations between mastery in basic algebraic expressions and trigonometry proficiency highlight the interconnectedness of algebra and trigonometry learning. Educators should prioritize reinforcing algebraic skills alongside trigonometric instruction to maximize students' mathematical achievement and problem-solving abilities.

**Table 10.** Significant Relationship Between Mastery in Rational Expressions and Proficiency in Trigonometry of Grade 9 Students

| Variable 1 | Variable 2 | N | R-Value | Sig.(2-tailed) | Interpretation |
|---|---|---|---|---|---|
| Mastery in Rational Expressions | Right Triangle Trigonometry Proficiency | 216 | 0.66 | 0.000 | Significant |
| Mastery in Rational Expressions | Pythagorean Theorem and Special Angles Proficiency | 216 | 0.36 | 0.000 | Significant |
| Mastery in Rational Expressions | Solving Angles and Elevation and Depression Proficiency | 216 | 0.77 | 0.000 | Significant |

Table 10 clearly demonstrates statistically significant positive relationships between Grade 9 students' mastery in rational expressions and their proficiency in key trigonometric areas: right triangle trigonometry, the Pythagorean theorem and special angles, and solving angles of elevation and depression. With all p-values at 0.000 and $\alpha = 0.05$, the null hypotheses are rejected, confirming that algebraic skills involving rational expressions are crucial for students' success in trigonometry. The first relationship, between mastery in rational expressions and proficiency in right triangle trigonometry, shows a strong correlation ($r = 0.66$). This indicates that students who are adept at simplifying, multiplying, and dividing rational expressions tend to excel in applying sine, cosine, and tangent ratios to solve right triangle problems. This finding is consistent with Boaler's (2016) research, which stresses that algebraic fluency is foundational for understanding trigonometric concepts, as it enables students to manipulate the algebraic forms of trigonometric equations effectively. Moreover, Rittle-Johnson (2017) highlights that procedural fluency in algebra supports conceptual understanding in mathematics, facilitating students' ability to connect symbolic manipulation with geometric reasoning. The second relationship, between mastery in rational expressions and proficiency in the Pythagorean theorem and special angles, is moderate ($r = 0.36$). While algebraic skills contribute to understanding these geometric concepts, the correlation is less pronounced, suggesting that spatial reasoning and geometric visualization also significantly influence mastery in this area. This aligns with findings by Small (2018) and Orbe and Espinosa (2020), who emphasize that geometric intuition and familiarity with special triangles (such as 30°-60°-90° and 45°-45°-90°) are essential for applying the Pythagorean theorem and understanding special angles. Additionally, Casanova et al. (2021) note that students' difficulties in this domain often stem from gaps in geometric reasoning rather than purely algebraic skills. The strongest correlation is observed between mastery in rational expressions and proficiency in solving angles of elevation and depression ($r = 0.77$). This very strong relationship suggests that students with solid algebraic skills in rational expressions are particularly successful in setting up and solving trigonometric equations

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in applied real-world contexts. Garcia and Santos (2025) highlight that the ability to translate word problems into algebraic expressions and solve them is critical for mastering applied trigonometry. Boaler (2016) also underscores that integrating algebraic manipulation with geometric understanding enhances students' problem-solving capabilities, especially in practical scenarios involving heights and distances. Furthermore, Reyes and Cruz (2022) and Tugas (2023) emphasize that strengthening algebraic competencies, including rational expressions, is vital for improving students' confidence and performance in trigonometry. Their studies suggest that targeted instructional strategies focusing on algebraic foundations can lead to better conceptual understanding and procedural fluency in trigonometric topics. In summary, the significant positive correlations between mastery in rational expressions and trigonometry proficiency highlight the interconnected nature of algebra and geometry in mathematics education. Algebraic skills, particularly in handling rational expressions, provide the necessary tools for students to engage deeply with trigonometric concepts and solve complex problems. Educators should therefore prioritize reinforcing these algebraic skills alongside trigonometric instruction to maximize student achievement and foster robust mathematical reasoning (Schoenfeld, 2017; Boaler, 2016).

**Table 11.** Significant Relationship Between Mastery in Geometric Properties of Triangles and Proficiency in Trigonometry of Grade 9 Students

| Variable 1 | Variable 2 | N | R-Value | Sig. (2-tailed) | Interpretation |
|---|---|---|---|---|---|
| Mastery in Geometric Properties of Triangles | Right Triangle Trigonometry Proficiency | 216 | 0.34 | 0.000 | Significant |
| Mastery in Geometric Properties of Triangles | Pythagorean Theorem and Special Angles Proficiency | 216 | 0.41 | 0.000 | Significant |
| Mastery in Geometric Properties of Triangles | Solving Angles and Elevation and Depression Proficiency | 216 | 0.72 | 0.000 | Significant |

The data in Table 11 reveals significant positive relationships between Grade 9 students' mastery of geometric properties of triangles and their proficiency in various trigonometry topics, including right triangle trigonometry, the Pythagorean theorem and special angles, and solving angles of elevation and depression. With a significance level (α) of 0.05 and all p-values at 0.000, the null hypotheses are rejected, confirming that a strong understanding of triangle geometry plays a crucial role in students' success in trigonometry. Regarding right triangle trigonometry, the association with mastery in geometric properties of triangles is moderate, as indicated by a Pearson r-value of 0.34. This suggests that students who have a solid grasp of the fundamental properties of triangles—such as the relationships between sides and angles—are more capable of effectively applying trigonometric ratios like sine, cosine, and tangent. This finding is supported by Clements (2018), who highlights that geometric reasoning forms the foundation for understanding and interpreting trigonometric concepts, enabling students to visualize and analyze the components of triangles more effectively. The connection between mastery in geometric properties of triangles and proficiency in the Pythagorean theorem and special angles is somewhat stronger, with a Pearson r-value of 0.41. This indicates that students' knowledge of geometric principles significantly aids their ability to understand and apply the Pythagorean theorem and recognize the properties of special triangles, such as the 30°-60°-90° and 45°-45°-90° triangles. Small (2018) and Orbe and Espinosa (2020) emphasize that spatial visualization and familiarity with these special triangles are essential for mastering these concepts, as they provide concrete examples where geometric and trigonometric ideas intersect. The strongest relationship is observed between mastery in geometric properties of triangles and proficiency in solving problems involving angles of elevation and depression, with a Pearson r-value of 0.72. This strong link suggests that students who possess a deep understanding of triangle geometry are better equipped to interpret and solve applied trigonometric problems in real-world contexts, such as calculating heights and distances. Garcia and Santos (2025) stress that spatial reasoning and the ability to visualize geometric scenarios are critical skills for success in these applications. Boaler (2016) further notes that integrating geometric understanding with algebraic manipulation enhances students' overall problem-solving abilities, particularly in practical trigonometry. Additionally, Reyes and Cruz (2022) and Tugas (2023) highlight the importance of reinforcing geometric foundations to boost students' confidence and performance in trigonometry. Their studies suggest that balanced instruction that develops both geometric intuition and algebraic skills leads to improved mathematical proficiency. In summary, the significant positive relationships between mastery in geometric properties of triangles and proficiency in trigonometry underscore the essential role of geometric reasoning in mathematics education. A strong foundation in triangle geometry not only supports procedural skills but also deepens conceptual understanding and enhances problem-solving capabilities. Therefore, educators should

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emphasize the development of geometric knowledge alongside algebraic instruction to maximize student achievement and readiness for advanced trigonometric concepts (Clements, 2018; Boaler, 2016; Schoenfeld, 2017).

**Research Question 4: Based on the findings of the study, what recommendations can be proposed to enhance the level of Grade 9 students' learning proficiency in Trigonometry through the mastery of basic mathematical prerequisites?**

In light of the findings of this study, several comprehensive recommendations are proposed to effectively enhance the learning proficiency of Grade 9 students in trigonometry by strengthening their mastery of essential mathematical prerequisites. It is important to intensify efforts to reinforce students' foundational algebraic skills, particularly in the areas of basic algebraic expressions and rational expressions. The study indicates that proficiency in these algebraic skills significantly impacts students' ability to understand and apply trigonometric concepts. Therefore, instructional programs should incorporate systematic and focused teaching strategies that emphasize the simplification of expressions, solving of linear and rational equations, and manipulation of algebraic fractions. Providing students with ample opportunities for guided practice, formative assessments, and real-time feedback will help solidify these skills. Such reinforcement will enable students to confidently and accurately handle the algebraic components that are integral to solving trigonometric problems, thereby reducing cognitive overload and increasing problem-solving efficiency. In addition to, the enhancement of students' understanding of geometric properties of triangles is also encouraged. Mastery of these geometric principles is foundational for success in various trigonometric topics, especially those involving the Pythagorean theorem, special angles, and applied problems such as angles of elevation and depression. To this end, educators should integrate instructional activities that develop spatial reasoning and geometric visualization skills. The use of dynamic geometry software, physical models, and interactive visual aids can facilitate deeper conceptual understanding by allowing students to explore and manipulate geometric figures actively. Emphasizing the relationships between sides and angles, as well as the properties of special right triangles, will strengthen students' ability to interpret diagrams accurately and apply geometric reasoning effectively in trigonometric contexts. Moreover, contextualizing trigonometry instruction through real-world applications is highly recommended to increase student engagement and foster meaningful learning. Incorporating practical problems that involve calculating heights, distances, and angles of elevation and depression will enable students to apply their algebraic and geometric knowledge in authentic scenarios. This approach not only enhances conceptual understanding but also develops critical thinking and analytical skills. Problem-based learning strategies that require students to formulate, set up, and solve trigonometric equations based on real-life situations should be embedded within the curriculum. Such contextualization bridges the gap between abstract mathematical concepts and tangible experiences, thereby motivating students and improving retention. Hence, providing targeted and differentiated support for students who exhibit difficulties with prerequisite skills is essential. The implementation of diagnostic assessments at the beginning and throughout the instructional period will help identify specific areas where students struggle. Based on these assessments, educators should design remediation programs tailored to address individual learning gaps. This may include small-group tutoring, peer mentoring, supplementary instructional materials, or technology-assisted learning tools. Additionally, scaffolding the learning process by gradually increasing the complexity of problems ensures that students build a strong conceptual and procedural foundation before progressing to more advanced trigonometric topics. This stepwise approach helps prevent frustration and promotes sustained academic growth. Finally, continuous and systematic monitoring of student progress through formative assessments is vital. Regular assessments provide timely feedback to both students and educators, allowing for the adjustment of instructional strategies to better meet learners' needs. Utilizing a variety of assessment methods, including quizzes, performance tasks, and reflective exercises, will offer a comprehensive picture of students' mastery of prerequisite skills and trigonometric concepts. This ongoing evaluation supports a responsive teaching approach that fosters mastery learning and improves overall student outcomes in trigonometry. The implementation of these detailed recommendations—strengthening algebraic foundations, enhancing geometric reasoning, contextualizing learning, providing targeted support, and monitoring progress will create a robust learning environment. Such an environment will empower Grade 9 students to develop higher proficiency, confidence, and success in trigonometry, laying a strong foundation for future mathematical learning.

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## Ethical Considerations

This study was conducted with strict adherence to ethical principles to protect the rights and welfare of all participants. Prior to data collection, informed consent was obtained from the Grade 9 students of Bernardo Lirio National High School and, where applicable, their parents or guardians. The purpose, procedures, potential benefits, and risks of the study were clearly explained to ensure that participation was fully voluntary and based on a comprehensive understanding of the research. Confidentiality and anonymity of the respondents were rigorously maintained throughout the study. Personal identifiers such as names were neither required nor recorded, thereby safeguarding the privacy of the participants. All data collected were treated with the utmost confidentiality and were used exclusively for the purposes of this research. Participation in the study was entirely voluntary, and respondents were informed of their right to decline participation or withdraw at any time without any penalty or adverse consequences. The research design was carefully crafted to minimize any potential physical, psychological, or emotional harm. The questionnaire items were formulated to avoid causing discomfort or distress, and the researcher was available to address any concerns that arose during data collection. Furthermore, this study was conducted only after securing formal approval from the Office of the School Principal of Bernardo Lirio National High School. The research also complied with the ethical guidelines by ensuring adherence to institutional and national standards governing research involving human subjects. The legal basis for this study includes compliance with the Republic Act No. 10173, or the Data Privacy Act of 2012, which mandates the protection of personal data and privacy of individuals. The study also aligns with the ethical standards prescribed by the Department of Education (DepEd) Order No. 40, s. 2012, which provides guidelines on the conduct of research in basic education institutions in the Philippines. In addition, this research incorporated the use of artificial intelligence (AI) tools to enhance data analysis and ensure accuracy. AI-assisted techniques were employed to process and interpret the collected data efficiently while maintaining strict confidentiality and ethical standards. The integration of AI contributed to a more rigorous and objective examination of the research findings. The data gathered were used solely for academic purposes related to this study, and the findings were reported with honesty and integrity, respecting both the participants and the research process.

## Conclusion

Based on the findings of the study, it can be concluded that Grade 9 students at Bernardo Lirio National High School generally demonstrate a high level of mastery in prerequisite mathematical competencies, particularly in basic algebraic expressions and rational expressions, while their understanding of geometric properties of triangles remains at a moderate level. This suggests that although students possess a solid foundation in algebraic concepts, there is still a need to strengthen their geometric reasoning skills, which are essential for comprehending trigonometric relationships. Furthermore, students exhibited a very high level of proficiency in trigonometry, especially in right triangle trigonometry (SOH-CAH-TOA), the Pythagorean Theorem, special angles, and in solving problems involving angles of elevation and depression, indicating their ability to apply mathematical concepts effectively in both theoretical and real-life contexts. The study also revealed a significant relationship between students' mastery of prerequisite mathematical competencies and their proficiency in trigonometry, confirming that stronger foundational skills in algebra and geometry are associated with higher levels of performance in trigonometric problem-solving. Therefore, it is concluded that reinforcing students' foundational competencies, particularly in algebra and geometry, is crucial in enhancing their overall understanding and achievement in trigonometry, as these serve as essential building blocks for advanced mathematical learning.

## Recommendations

In light of the findings and conclusions of the study on the relationship between prerequisite mathematical competencies and trigonometry proficiency among Grade 9 students at Bernardo Lirio National High School, several recommendations are proposed. Teachers are encouraged to implement structured and consistent instructional strategies, such as brief daily spiral reviews focusing on essential prerequisite skills, including factoring quadratics and simplifying complex fractions, alongside error-analysis activities that allow students to identify and correct misconceptions in algebraic processes. Such approaches can strengthen students' foundational competencies before engaging with more complex trigonometric concepts. Furthermore, educators are advised to integrate dynamic and interactive learning tools, including geometry software like GeoGebra or Desmos, complemented by hands-on activities such as constructing right triangles, to enhance students' spatial reasoning and deepen their understanding of key principles like the Pythagorean Theorem. At the institutional level, schools may adopt project-based learning approaches that contextualize trigonometric concepts in real-world applications, such as campus-based surveying activities where students design and use simple instruments to measure angles and calculate heights. Additionally, school

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administrators are encouraged to promote collaborative practices through regular vertical alignment meetings among mathematics teachers across grade levels to ensure coherence in instruction and terminology, as well as to allocate resources for adaptive learning technologies that provide timely and individualized feedback on students' skill gaps. Finally, future researchers are recommended to conduct longitudinal studies that trace the development of mathematical competencies from foundational levels to advanced topics, as well as to explore affective variables, such as mathematics anxiety, that may influence students' performance in trigonometry. These efforts will contribute to a deeper understanding of how both cognitive and emotional factors shape mathematics learning outcomes.

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International Journal of Research on Multidisciplinary Studies
*Online ISSN: 3116-4137 | Print ISSN: 3116-4145*
*Volume 1, Issue 6, pp. 77-93, July 2026*
https://ijroms.com
*Original Article*

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