



Mathematical investigation: Investigating the application of the pythagorean theorem in determining heights and distances in real-life situations

Cinderella A. Centeno¹, Jaycel D.C. Juan^{1*}, Jamilla C. Samson¹, Mark Ren D. Villaflor¹, Dr. Maulina² and Syarif Hidayat²

¹ Nueva Ecija University of Science and Technology, San Isidro, Nueva Ecija, Philippines

² Muhammadiyah University of Kendari, Kendari, Sulawesi Tenggara, Indonesia

*Corresponding author: Jaycel D.C. Juan

Received 13 May 2026; Accepted 2 Jul 2026; Published 14 Jul 2026

DOI: <https://doi.org/10.64171/JAES.6.4.17-21>

Abstract

This investigation examines the application of the Pythagorean Theorem in determining heights and distances in real-life situations and evaluates its accuracy as a practical measurement tool. Using actual field measurements and mathematical computations, the study compares directly measured values with those obtained through the Pythagorean Theorem. Percentage accuracy was calculated to determine the reliability of the computed results. The findings reveal that the computed measurements closely correspond to the actual measurements, with accuracy values ranging from 97.73% to 100.00% and a mean accuracy of 99.07%. The results demonstrate that the Pythagorean Theorem provides an efficient, reliable, and cost-effective method for measuring heights and distances that are difficult or unsafe to determine directly. Comparative analysis confirms that the theorem can be applied successfully in various real-life contexts, including construction, surveying, navigation, and engineering. The study concludes that the Pythagorean Theorem remains a fundamental mathematical principle with significant practical value and broad applications beyond the classroom in both academic and professional settings.

Keywords: Pythagorean theorem, Heights, Distances, Measurement accuracy, Real-life applications

Introduction

Mathematics functions as a tool to explain, measure, and understand the world. It covers numbers and formulas. It also provides methods to interpret and navigate daily life. The Pythagorean Theorem stands as a core principle in trigonometry and applied mathematics. Pythagoras introduced this concept over two thousand years ago. It defines the relationship between sides of a right triangle. The formula reads $a^2 + b^2 = c^2$. c represents the hypotenuse. a and b represent the other two sides.

This formula solves for unknown lengths, heights, and distances that are often difficult or unsafe to measure directly. The Pythagorean Theorem serves as a fundamental concept in geometry and supports the development of trigonometric principles, making it widely applicable in practical measurement situations.

Trigonometry links angles and sides of triangles. Together, the theorem and ratios like sine, cosine, and tangent support work in navigation, construction, engineering, architecture, surveying, astronomy, sports, and design. People use these tools to build structures, map land, find shortest paths, or calculate slope length. They deliver accurate solutions to real problems (Gupta, 2021; Namli, 2024; Budd, 2021) [5, 8, 3].

Many students struggle to understand and apply the theorem. Common errors include misidentifying parts of a right triangle. Others make mistakes during calculation. Many fail to turn real

situations into mathematical models. These issues limit use in practical settings (Ardhiansah, Muhtadi & Apiati, 2025; Sandra & Suryadi, 2025) [2, 12].

Performance varies based on problem format. Data shows students score higher when problems relate to daily life. Abstract questions lead to lower results. Difficulties persist in interpreting word problems and explaining ideas (Namli, 2024; Tajrumi, Murni & Roza, 2025) [8, 16]. Learning styles also shape progress. Visual, auditory, and kinesthetic learners use different strategies to grasp the concept (Siswono & Harini, 2026; Muslim, Sehuwaky & Lapele, 2023) [15, 7].

Educators use methods to close these gaps. Approaches include interactive tools, realistic mathematics education, structured examples, and problem solving frameworks. These connect abstract ideas to experience (Putri, Aziz & Suprayitno, 2025; Septimianti & Hiltrimartin, 2022; Apriani & Mahmudi, 2025; Sianipar & Wustqa, 2025) [11, 13, 1, 14]. Other efforts build computational thinking. New proofs and advanced models deepen understanding. These steps strengthen knowledge and application (Nurwita, Kusumah & Priatna, 2022; Jackson & Johnson, 2024; Ejegwa *et al.*, 2022) [9, 6, 4].

This study, entitled “Investigating the Application of the Pythagorean Theorem in Determining Heights and Distances in Real-Life Situations,” aims to examine the use of the Pythagorean Theorem in solving practical measurement problems involving heights and distances. Specifically, it

focuses on determining the heights of trees, buildings, and poles, as well as the distances between points. Furthermore, the study seeks to evaluate the accuracy, effectiveness, advantages, and limitations of the theorem when applied to real-life situations (Apriani & Mahmudi, 2025) ^[1].

Statement of the problem

This study aims to investigate the application of the Pythagorean Theorem in determining heights and distances in various real-life situations.

Specifically, it seeks to answer the following questions:

- How can the Pythagorean Theorem be applied in measuring heights and distances that are difficult or impossible to measure directly?
- In what real-life situations can the Pythagorean Theorem be used to determine heights and distances accurately?
- What procedures are involved in applying the Pythagorean Theorem to determine heights and distances in real-life situations?
- How accurate are the measurements obtained using the Pythagorean Theorem when compared with actual measurements?
- What are the advantages and limitations of using the Pythagorean Theorem in determining heights and distances in real-life situations?

Methods and Research Design

Research design

This study will employ a descriptive-quantitative research design to investigate the application of the Pythagorean Theorem in determining heights and distances in real-life situations. The study will involve the collection of actual measurements from selected objects and locations, such as trees, buildings, poles, and distances between points. The measurements obtained using the Pythagorean Theorem will be compared with actual measurements to determine the accuracy and practicality of the theorem in solving real-life measurement problems.

The descriptive aspect of the study will explain how the theorem is applied in various situations, while the quantitative aspect will analyze the numerical data obtained from the measurements. This design is appropriate because it enables the researchers to evaluate the effectiveness, accuracy, advantages, and limitations of the Pythagorean Theorem in determining heights and distances.

Research materials

The researchers will use the following materials in gathering data:

- **Measuring tape** - To obtain actual measurements of heights and distances for comparison.
- **Scientific calculator** - To perform computations using the Pythagorean Theorem.
- **Observation sheet** - To record measurements, computations, and observations during the investigation.
- **Data recording form** - To organize and document the measured and computed values.

- **Reference materials** - Books, journals, and online resources related to the Pythagorean Theorem and its practical applications.

The materials will enable the researchers to compare actual measurements with measurements obtained through the application of the Pythagorean Theorem.

Research setting

The study will be conducted at Nueva Ecija University of Science and Technology (NEUST) San Isidro Campus during the Academic Year 2026–2027. The campus provides an appropriate environment for the investigation because it contains various structures and locations, such as buildings, trees, flagpoles, walkways, and open spaces that can be used in applying the Pythagorean Theorem to determine heights and distances in real-life situations.

Respondents/Participants

This study does not require student respondents since the focus is on investigating the application of the Pythagorean Theorem in determining heights and distances in real-life situations. Instead, the subjects of the study will consist of selected real-life objects and locations within the Nueva Ecija University of Science and Technology San Isidro Campus, such as trees, buildings, flagpoles, and measured distances between points. These objects and locations will be selected purposively based on their suitability for applying the Pythagorean Theorem in determining heights and distances.

Instruments and other data collection techniques

The researchers will employ the following instruments for data collection:

- **Measuring tape** - Used to obtain actual measurements of heights and distances for comparison with computed values.
- **Scientific calculator** - Used to perform calculations involving the Pythagorean Theorem and basic trigonometric concepts.
- **Observation sheet** - Used to record actual measurements, computed measurements, procedures, and observations during the investigation.
- **Data Recording form** - Used to organize and document the collected data, computations, and results.

The researchers will gather actual measurements from selected objects and locations within the campus. The measurements obtained through the application of the Pythagorean Theorem will then be compared with the actual measurements to determine the accuracy and practicality of the theorem in solving real-life measurement problems.

Procedure

The study will follow the procedures below:

- The researchers will seek permission from the campus administration to conduct the investigation within the school premises.
- The researchers will identify and select appropriate objects and locations within the Nueva Ecija University of Science

and Technology San Isidro Campus, such as trees, buildings, flagpoles, and measured distances between points.

- Actual measurements of the selected objects and distances will be obtained using measuring tools whenever direct measurement is possible.
- The researchers will apply the Pythagorean Theorem using the collected measurements to compute the corresponding heights and distances of the selected objects and locations.
- The computed measurements will be compared with the actual measurements to determine the accuracy and practicality of the theorem.
- The collected data will be organized, tabulated, and analyzed.
- Conclusions and recommendations will be formulated based on the findings of the investigation.

Data analysis

The collected data will be analyzed using the following statistical methods:

- Mean** - To determine the average measurements obtained from the investigation.
- Percentage error** - To determine the difference between the computed measurements and the actual measurements.
- Percentage accuracy** - To evaluate the accuracy of the Pythagorean Theorem in determining heights and distances.
- Comparative analysis** - To compare computed and actual measurements and determine the effectiveness and accuracy of the Pythagorean Theorem in different real-life situations.
- Descriptive interpretation** - To explain and summarize the findings based on the computed results.

These analyses will provide a basis for evaluating the effectiveness, accuracy, advantages, and limitations of the Pythagorean Theorem in determining heights and distances in real-life situations.

Results and Discussion

The researchers measured selected objects and locations within the Nueva Ecija University of Science and Technology (NEUST) San Isidro Campus and applied the Pythagorean Theorem to determine heights and distances. The computed measurements were then compared with the actual measurements to evaluate the accuracy and practicality of the theorem.

Illustrative computation for flagpole A

Object: Flagpole A

Given

- Distance from the base of the flagpole to the observation point (a) = 4m
- Length from the top of the flagpole to the observation point (hypotenuse, c) = 7.16m

Find: Height of the flagpole (b)

Solution

Using the Pythagorean Theorem:

$$a^2 + b^2 = c^2$$

Substitute the given values:

$$4^2 + b^2 = 7.16^2$$

$$16 + b^2 = 51.27$$

$$b^2 = 51.27 - 16$$

$$b = \sqrt{35.27}$$

$$b = 5.94m$$

Therefore, the computed height of the flagpole is 5.94 meters.

Comparing with actual measurement

Actual height measured = 6.00m

Difference:

$$\text{Difference} = |\text{Actual} - \text{Computed}|$$

Substitute:

$$\text{Difference} = |6.00 - 5.94|$$

$$\text{Difference} = 0.06$$

Percentage Error:

$$\text{Percentage Error} = \left| \frac{\text{Actual} - \text{Computed}}{\text{Actual}} \right| \times 100$$

Substitute:

$$\text{Percentage Error} = \left| \frac{6.00 - 5.94}{6.00} \right| \times 100$$

$$\text{Percentage Error} = \left| \frac{0.06}{6.00} \right| \times 100$$

$$\text{Percentage Error} = 0.01 \times 100$$

$$\text{Percentage Error} = 1\%$$

Percentage Accuracy:

$$\text{Percentage Accuracy} = 100\% - \text{Percentage Error}$$

Substitute:

$$\text{Percentage Accuracy} = 100\% - 1\%$$

$$\text{Percentage Accuracy} = 99\%$$

Table 1: Comparison of actual and computed measurements

Object/Location	Actual measurement (m)	Computed measurement (m)	Difference (m)	Percentage error (%)	Percentage accuracy (%)
Flagpole A	6.00	5.94	0.06	1.00	99.00
Flagpole B	2.50	2.50	0.00	0.00	100.00
Campus entrance wall	2.50	2.50	0.00	0.00	100.00
Three-story building	11.00	10.75	0.25	2.27	97.73
Distance between education building to exit gate	35.00	34.51	0.49	1.40	98.60

Mean accuracy percentage:

$$\bar{x} = \frac{\sum x}{n}$$

Substitute:

$$\bar{x} = \frac{99.00 + 100 + 100 + 97.73 + 98.60}{5}$$

$$\bar{x} = \frac{495.33}{5}$$

$$\bar{x} = 99.07\%$$

The mean percentage accuracy of 99.07% indicates that the computed measurements were highly consistent with the actual measurements.

Discussion

The measurements obtained using the Pythagorean Theorem were compared with the corresponding actual measurements to determine the accuracy and practicality of the theorem. The percentage errors ranged from 0.00% to 2.27%, while the percentage accuracies ranged from 97.73% to 100.00%.

Among the objects measured, Flagpole B and the Campus Entrance Wall obtained the highest percentage accuracy of 100%, indicating no difference between the actual and computed measurements. Meanwhile, the Three-Story Building obtained the lowest percentage accuracy of 97.73%, although the difference between the actual and computed measurements remained relatively small.

The results suggest that the Pythagorean Theorem can provide accurate estimates of heights and distances when the measurements involved form a right triangle. The computed values closely matched the actual measurements, demonstrating the usefulness of the theorem in practical measurement situations.

The mean percentage accuracy of the measurements was 99.07%, indicating a high level of accuracy. This suggests that the Pythagorean Theorem is a reliable mathematical tool for determining heights and distances that are difficult or unsafe to measure directly.

However, the accuracy of the results depends on the precision of the measurements collected in the field. Any errors in measuring distances or identifying the correct dimensions of the right triangle may affect the computed results.

Overall, the findings indicate that the Pythagorean Theorem is an effective and practical method for solving real-life problems involving heights and distances. The high accuracy percentages obtained in the investigation demonstrate its usefulness and reliability in practical applications such as surveying, construction, engineering, navigation, and land measurement. The results further confirm that the theorem can be used as an alternative method for determining measurements that are difficult or unsafe to obtain directly.

Conclusion

Based on the findings, the Pythagorean Theorem can be used to determine heights and distances when measurements form a right triangle. It can be used for various community, work, and individual activities such as determining vertical heights of buildings, measuring distances of travel to hold, determining

horizontal distances to travel, and designing supports/balancing structural loads. The theorem works best when the known sides of the triangle are measured accurately. The theorem gives answers that are almost the same as those measured directly.

The theorem provides an efficient, reliable, and cost-effective method for measuring heights and distances that are difficult or unsafe to determine directly. It shows that an abstract mathematical idea is useful outside of the classroom. In addition to that, the theorem as a contemporary mathematics idea connects to more advanced content and studies in trigonometry, navigation, engineering, and other disciplines/fields that rely on mathematics. The findings demonstrate that the Pythagorean Theorem is highly useful in real-life applications and provides a practical means of understanding and measuring various aspects of the physical world.

Recommendation

Based on the findings, the study recommends that hands-on learning, which would include field measurement, should be incorporated along with the Pythagorean Theorem instruction. Activities that involve the measurement of the height of buildings, the distance to different locations, or the use of ladders can show students the importance of the theorem. Diagrams and measurement software can aid the students in identifying right triangles and understanding the theorem's application to avoid errors.

This research can be furthered with the integration of the Pythagorean Theorem with other mathematical concepts and techniques. This research can also be extended with the application of the Pythagorean Theorem to fields such as the planning of urban spaces or the mitigation of disaster. New research should also incorporate a comparison of the Pythagorean Theorem with other measurement techniques (e.g., clinometers, GPS) and study different instructional strategies to determine the impact on students' theorem application skills. The aim of all of this research should be to develop students' understanding and appreciation of the theorem.

References

1. Apriani Y, Mahmudi A. Design worked examples for mathematical problem solving in real-life contexts: A focus on learning the Pythagorean theorem. *Int J Multidiscip Case Rep*, 2025. Available from: <https://doi.org/10.47191/ijmcr/v13i10.14>
2. Ardiansah D, Muhtadi D, Apiati V. Analysis of cognitive difficulties of junior high school students in solving the problem of Pythagorean theorem. *Koordinat J MIPA*, 2025. Available from: <https://doi.org/10.24239/koordinat.v6i1.133>
3. Budd C. Saving whales using Pythagoras. *Plus Magazine*, 2021. Available from: <https://plus.maths.org/content/saving-whales-using-pythagoras>

4. Ejegwa PA, Wen S, Feng Y, Zhang W, Liu J. A three-way Pythagorean fuzzy correlation coefficient approach and its applications in deciding some real-life problems. *Appl Intell.* 2023;53(1):226-237. Available from: <https://doi.org/10.1007/s10489-022-03415-5>
5. Gupta A. Pythagorean theorem research paper 2021. *J Res Appl Math.* 2021;7(7):13-18. Available from: <https://www.questjournals.org/jram/papers/v7-i7/C07071318.pdf>
6. Jackson NK, Johnson C. Five or ten new proofs of the Pythagorean theorem. *Am Math Mon.* 2024;131(9):739-752. Available from: <https://doi.org/10.1080/00029890.2024.2370240>
7. Muslim R, Schuwaky N, Lapele DA. Analysis of problem-solving capabilities judging from student learning styles in solving the problem of the Pythagorean theorem. *Integral J Math Educ,* 2023. Available from: <https://jurnal.iainambon.ac.id/index.php/Integral/article/view/4295>
8. Namli Ş. Comparing ninth-grade students' approaches to trigonometric ratio problems through real-world and symbolic contexts. *Int Educ Stud.* 2024;17(4):70-84. Available from: <https://doi.org/10.5539/ies.v17n4p70>
9. Nurwita F, Kusumah YS, Priatna N. Exploring students' mathematical computational thinking ability in solving Pythagorean theorem problems. *Al-Jabar J Pendidik Mat.* 2022;13(2):273-287. Available from: <https://ejournal.radenintan.ac.id/index.php/al-jabar/article/view/12496/5759>
10. Powell A. Pythagorean Theorem, 2023. Available from: <https://albamatematika.wordpress.com/wp-content/uploads/2024/07/1-libri-pythagorean-theorem-and-its-many-proofs-cut-the-knot2-58-pages-122-proofs.pdf>
11. Putri VA, Aziz A, Suprayitno I. Development of T-Solve interactive learning media with Polya approach on Pythagorean theorem. *JUWARA,* 2025. Available from: <https://doi.org/10.58740/juwara.v5i1.401>
12. Sandra Y, Suryadi D. Students' learning obstacles and didactical anticipation in learning the Pythagorean theorem. *Proc Int Conf Res Educ.* 2025;1(1):154-162. Available from: <https://doi.org/10.24071/icre.v1i1.14>
13. Septimianti D, Hiltrimartin C. Development of the Pythagorean theorem learning path with the PMRI approach using the context of tiled tangram. In: *Proceedings of the International Conference on Education.* Atlantis Press, 2022. Available from: <https://doi.org/10.2991/assehr.k.220403.010>
14. Sianipar WA, Wustqa DU. Design worked examples for mathematical literacy: A focus on learning the Pythagorean theorem. *Int J Multidiscip Case Rep,* 2025. Available from: <https://doi.org/10.47191/ijmcr/v13i12.07>
15. Siswono TYE, Harini NV. Analyzing students' contextual problem-solving on the Pythagorean theorem based on learning styles. *MATHEdunesa,* 2026. Available from: <https://ejournal.unesa.ac.id/index.php/mathedunesa/article/view/67613>
16. Tajrumi AN, Murni A, Roza Y. Analysis of students' mathematical communication ability in solving problems on the Pythagorean theorem. *Gantang J,* 2025. Available from: <https://ojs.umrah.ac.id/index.php/gantang/article/view/7282>.