Education

Mathematical investigation: Practical uses of right triangles for indirect measurement

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Abstract

The purpose of this study was to determine the potential usability of 45°-45°-90° special right triangles to solve the problem of estimating an unknown height and distance. A qualitative-descriptive method was employed, through documentation research, by examine reliable academic texts, and instructional books/references issued not later than 2021. This research would explain how the 45°-45°-90° triangle, with a fixed ratio between its sides of 1:1:2, may make it easy for measuring distances to inaccessible heights and objects like trees, buildings, utility poles and etc. The analysis indicates that the indirect method can successfully resolve the stated issue since with accurate adjustment of 45° of the angle of elevation, the perpendicular distance between the object and observer and the height of the object would be equal and can be calculated quickly. Precise but minor errors limit its real-world use.

Keywords: Special right triangles, 45°-45°-90° Triangle, Indirect measurement, Trigonometric applications, Real-world measurement

Introduction

Mathematics is an essential discipline that helps individuals understand and solve problems encountered in daily life. Among its many applications, geometry and trigonometry provide practical methods for measuring objects and distances that are difficult or impossible to measure directly. One of these methods is indirect measurement, which uses mathematical relationships to determine unknown lengths, heights, or distances without physical contact. Right triangles play a significant role in this process because their properties allow accurate calculations based on known measurements and angles.

A special type of right triangle, the 45°–45°–90° triangle, is particularly useful for indirect measurement. Since its two acute angles are equal, the lengths of its legs are also equal, creating a simple and reliable relationship between its sides. This property can be applied in measuring the height of buildings, trees, utility poles, and other structures by using basic geometric principles. The simplicity of the 45°–45°–90° triangle makes it an effective tool for students and community members who need practical measurement techniques in real-world situations.

In the mathematics curriculum, student-teachers are expected to acquire knowledge of content, pedagogy and teaching techniques for trigonometric angles. Even though any three tripartite angles that sum up to 180° is justifiable, the case of 30°-60°- 90° and 45°-45°-90° are exemplary (Spangenberg, 2021). Student-teachers still find it extremely difficult to handle the topic.

The 45°–45°–90° triangle is recognized as one of the most important special right triangles because its side lengths of the constant ratio 1:1:$\sqrt{2}$. This relationship allows mathematicians and students to determine unknown side lengths without repeatedly applying the Pythagorean Theorem. Educational literature emphasizes that understanding these fixed ratios helps learners solve geometric and trigonometric problems more efficiently (Ck - foundation, 2021).

Despite the widespread use of right triangles in geometry and trigonometry, few studies have explored the effectiveness and practical application of indirect measurement techniques in real-world educational and community contexts. Existing research often emphasizes theoretical concepts, leaving a gap in understanding how these methods can be applied to solve everyday measurement challenges and enhance learning experiences (Suqing Zhou, 2026).

While previous studies have explored the mathematical principles of right triangles and trigonometry, limited research has examined their practical application in indirect measurement of inaccessible heights and distances in real-world settings. Furthermore, there is insufficient evidence regarding the effectiveness, accuracy, and educational value of using right-triangle-based measurement techniques among students and community users. This study seeks to address this gap by investigating practical applications of right triangles in indirect measurement and evaluating their usefulness in solving everyday measurement problems.

Goal of the study

The primary goal of the study is to investigate the practical uses of the 45°–45°–90° right triangle based on existing literature in

indirect measurement. Specifically, it aims to determine how this special right triangle can be applied to measure inaccessible heights and distances in real-life situations. Furthermore, he studies seeks to identify the accuracy of the results obtained, the challenges students encounter when using this method, and the limitations of applying the 45°–45°–90° triangle in practical measurement.

Methodology and Procedure

Methodology

This chapter explains how we conducted our study in the 45°-45°-90° triangle. We followed steps to gather and analyze information about this triangle.

Research design

This study employed a qualitative descriptive research design to explore practical uses of indirect measurement, perceptions, and understanding of using the 45°–45°–90° right triangle based on document analysis. The study focused on how 45°–45°–90° right triangl apply the concept in real-life situations, the challenges they encounter during the process, and the insights they gain from using indirect measurement techniques.

Data sources

This study used reliable academic sources published from 2021 onward, including OpenStax Precalculus 2e, CK-12 Foundation, and LibreTexts. These references provided the theoretical foundation for understanding the 45°–45°–90° triangle, its side ratio, and its application in trigonometry and indirect measurement.

Variables of the study

The independent variable of the study is the use of the 45°–45°–90° right triangle in applying indirect measurement this referring to the properties of the right triangle and accuracy and effectiveness measurements obtained through indirect measurement.

Data gathering procedure

The researchers gathered information from reliable academic sources published from 2021 onward, including textbooks, journal articles, and educational websites related to the 45°–45°–90° triangle, trigonometry, and indirect measurement. The collected information was organized, reviewed, and analyzed to identify concepts, applications, and findings relevant to the study.

Data analysis

The researcher analyze the exciting study's about indirect measurement by identifying common themes and pattern. The responses were grouped according to experiences, challenges, and perceptions of using the 45°–45°–90° triangle in indirect measurement

Analytical framework

This study follows the Input–Process–Output (IPO) framework. The input includes the properties of the 45°–45°–90° right triangle, measuring tools, and selected objects for measurement. The process involves measuring the horizontal distance from the object, applying the properties of the 45°–45°–90° triangle, and computing the estimated height of the object through indirect measurement. The output consists of the estimated measurements obtained, the practical applications of the 45°–45°–90° triangle, and the findings regarding its usefulness and limitations in measuring inaccessible heights and distances.

Reliabilty and Validity

The study ensured validity by using reliable and recent academic sources published from 2021 onward that are relevant to the 45°–45°–90° triangle and indirect measurement. Reliability was maintained by selecting credible references, comparing information from multiple sources, and consistently analyzing the collected literature to ensure accurate and dependable findings.

Ethical consideration

The study followed ethical research practices by using recent and reliable academic sources (2021 onward) and properly citing all references. All information was accurately presented without fabrication or misinterpretation and used only for academic purposes.

Result and Discussion

Table 1: Frequency matrix of findings from the reviewed literature on the 45°–45°–90° triangle in indirect measurement

Findings From Excisting studies	Spangeberg (2021)	CK - 12 (2021)	OpenStax (2021)	Libre Texts	Suqing Zhou (2026)	Frequency (f)	%
Application of the 45°–45°–90° triangle in measuring inaccessible heights and distances	✓	✓	✓	✓	✓	5	100
The 1:1:√2 side ratio simplifies indirect measurement computations		✓	✓	✓	✓	4	80
The method provides accurate and reliable measurement results	~	✓	✓	✓	✓	4	80
The triangle enhances the teaching and learning of geometry and trigonometry	✓	✓	✓	~	~	3	60
Students experience difficulty in applying the concept of the 45°–45°–90° triangle	✓	~	~	~	~	1	20
Limited studies focus on the practical application of indirect measurement	~	~	~	~	✓	1	20

✓ = Finding was reported in the reviewed study; ~ = Finding was not explicitly reported; f = frequency of reviewed studies reporting the finding; N = 5 reviewed studies.

Interpretation

Table 1 presents the frequency matrix of findings obtained from the five reviewed studies. All five studies (f = 5, 100%) reported that the 45°–45°–90° triangle is applicable in measuring inaccessible heights and distances through indirect measurement. Four studies (f = 4, 80%) emphasized that the fixed side ratio of 1:1:√2 simplifies computations and produces reliable measurement results. Three studies (f = 3, 60%) discussed the educational value of the triangle in improving students' understanding of geometry and trigonometry. Only one study (f = 1, 20%) identified students' difficulty in applying the concept, while one study (f = 1, 20%) highlighted the limited research on the practical application of indirect measurement. These findings support the objectives of the present study by demonstrating the usefulness, effectiveness, and research gap related to the application of the 45°–45°–90° triangle in indirect measurement.

The investigation found out that the use of 45°-45°-90° in indirect measurement are useful method for estimating the height of the object, The estimated heights were close to the actual heights. showing that the method can provide reliable results when the measurements are done carefully.

The results show that the 45°-45°-90° right triangle is useful for estimating the heights of inaccessible objects through indirect measurement. Its equal-leg relationship (1:1:V2) makes the computation of height equal to the measured horizontal distance, making calculations simpler. Small differences in the measurements may occur due to human error, uneven ground, or inaccurate setting of the 45° angle of elevation. Overall, the method is practical and effective for basic indirect measurement of heights and distances.

Conclusion

It shows that using a 45°-45°-90° right triangle is one of the easiest ways to measure the tall things like trees, buildings or poles without climbing them. The best part about this specific triangle is that the distance you walk away from the object on the ground is exactly the same as the height of the object. You don't need a calculator or hard math formulas, which make it super useful in our daily lives. It is not always perfectly exactly if the ground is bumpy or if you don't look at the perfect angle. However even this small errors, it still gives a very reliable estimate. In the end, we proved that mathematics is not just for classroom discussions, It is highly useful skill that anyone can use in real life.

Recommendation

After careful investigation and based on the conclusions and findings drawn from this research, the following recommendations are proposed to strengthen the application, accuracy, and further research of the 45°-45°-90° triangle for indirect measurements:

- **To future researchers**

Researchers could undertake a comparative study on the use of 45°-45°-90° triangles versus the 30°-60°-90° triangles as well as to consider general trigonometric ratios to find out which is better used in certain environment and conditions. Mixed method approach could be used in future studies to include not only analysis of documents but as well as real fieldwork experiments. Involving the students or members of the community in the measuring activities and allow the comparisons between direct measurement and indirect estimation of actual structures, the researchers will experience first hand accuracy challenges and documented problems encountered in fieldwork. Further researches should be devoted to the specific studies about identifying potential error sources like ground condition, calibration error of angle measurement, errors in measuring distances and observer's height and formulating ways of minimizing inaccuracies. Integration of locally used Filipino textbooks, local engineering textbooks and provincial studies will allow proper contextualization.

- **To educators and schools**

It is suggested that geometry and trigonometry education in schools be more inclined to practical fieldwork. The use of cheaper tools like measuring tapes, protractors or simple angle finders for school field activities would help them learn to apply principles into real-world situations. Additional instructional materials such as simplified guide material sand worksheets with step-by-step directions to use measurement tools, highlight of possible errors and corresponding corrections could be prepared and made accessible by the schools to their students. Workshops should be conducted among teachers and students regarding proper usage of measurement tools, proper angle calibration and data interpretation in order to alleviate difficulty they encounter in learning this topic.

- **To the community and end-users**

There is a need to prepare and distribute clear, and easy-to-understand guides both in Filipino and English language about estimating height and distances without the use of specialized instruments among farmers, construction workers and local people who do not possess higher education in mathematics. The community and local workers could be encouraged to use cheap and available or locally-made measurement tools in their estimations.

- **To curriculum planners**

The math curriculum must put greater emphasis on the practical applications and real-life uses of mathematics. Students must learn not just to memorize abstract trigonometric ratios but rather learn when and where to apply them effectively. Furthermore, discussions concerning limitations of this method such as less accuracy on uneven terrain or on very tall objects should be integrated to foster critical thinking among students.

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