

ANALYSIS OF COGNITIVE DIFFICULTIES OF JUNIOR HIGH SCHOOL STUDENTS IN SOLVING THE PROBLEM OF PYTHAGOREAN THEOREM

Dian Ardhiansah¹, Dedi Muhtadi^{1*}, Vepi Apiati¹

¹Department of Mathematics Education, Siliwangi University, West Java, Indonesia

ARTICLE INFO

Article History

Accepted: 07 Jan 2025

Revised: 08 May 2025

Accepted: 15 May 2025

Published: 03 Jun 2025

Keywords:

Cognitive Difficulties

Teaching Methods

Problem Solving

Pythagorean Theorem



©Koordinat : Jurnal Pembelajaran
Matematika dan Sains is licensed under a
[Creative Commons Attribution-
ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).

ABSTRACT

This study aims to analyze students' difficulties in solving problems related to the Pythagorean Theorem and identify the causative factors. The qualitative case study approach was used by involving 30 grade VIII students from SMP Negeri 8 Tasikmalaya who were selected based on the complexity of the mistakes they made. The research instruments included written tests, in-depth interviews, and classroom observations. The data were analyzed using thematic analysis to identify patterns of difficulty and their causative factors. The results showed four main categories of students' difficulties, namely: (1) conceptual errors (70% difficulty identifying the oblique side of a right triangle); (2) procedural errors (65% did not follow the calculation steps correctly); (3) errors in interpreting story questions (60% cannot convert problem information into mathematical models); and (4) math anxiety (50% feel nervous about facing problems with large numbers). The causative factors include monotonous teaching methods, lack of use of teaching aids, and low motivation to learn. The discussion highlighted the importance of interactive and contextual learning to overcome these difficulties. Recommendations include the use of visual media, the integration of technology to reinforce concepts, and approaches that are appropriate to students' learning styles. This research emphasizes the need for innovative pedagogical strategies to improve students' understanding and problem-solving skills.

Copyright © 2025 Dian Ardiansyah, Dedi Muhtadi,
Vepi Apiati

Corresponding Author:

Dedi Muhtadi, Mathematics Education, Siliwangi University, West Java, Indonesia

Email: dedimuhtadi@unsil.ac.id

How to cite:

Ardiansyah, D., Muhtadi, D., & Aviati, V. (2025). Analysis of Cognitive Difficulties of Junior High School Students in Solving The Problem of Pythagorean Theorem. *Koordinat Jurnal Pembelajaran Matematika dan Sains*, 6(1), 25-37. <https://doi.org/10.24239/koordinat.v6ii.133>.

INTRODUCTION

Pythagorean theorem is one of the fundamental concepts in mathematics learning at the junior high school (junior high school) level. This concept is not only the basis for understanding geometry but also has wide practical applications in everyday life, such as distance calculation, construction, and architectural design (Ritonga & Hasibuan, 2022). However, in reality, many students have difficulties in understanding and applying this theorem, ranging from conceptual errors to the inability to solve theorem-based story problems (Khoerunnisa & Sari, 2021). This condition indicates that there are obstacles in the learning process that can affect students' overall logical, analytical, and problem-solving skills (Indrawati *et al.*, 2024; Nafisah *et al.*, 2024; Nurmayunita, *et al.*, 2024).

This difficulty becomes a significant problem because the concept of the Pythagorean Theorem is an important prerequisite for understanding other geometric materials, such as triangles, circles, and trigonometry, which form the foundation for advanced mathematics education (Meika *et al.*, 2022). Furthermore, students who fail to understand this concept will find it difficult to apply mathematical knowledge in daily life or the future world of work, which demands high-level mathematical skills (Umar *et al.*, 2021). In addition, studies show that students' difficulties are often exacerbated by monotonous teaching methods, lack of use of visual media, and low motivation for students to learn mathematics (Setiawan, 2024; Reza *et al.*, 2024; Mayani, 2024).

Previous research has explored various aspects related to students' difficulties on the Pythagorean Theorem. For example, Indrawati *et al.* (2024) found that many students experienced procedural errors when working on questions, such as applying the wrong formula and failing to verify the

answers. Ritonga and Hasibuan (2022) identified that conceptual errors, such as confusion distinguishing the oblique and right-hand sides, are one of the main obstacles. In addition, Khoerunnisa and Sari (2021) stated that students often have difficulty understanding story problems, especially in connecting the context of the problem with relevant mathematical models. However, while this study provides insight into the types of student errors, most do not delve into the factors that cause errors, such as the influence of math anxiety or differences in students' learning styles.

Furthermore, there has not been much research exploring concrete solutions based on interactive learning approaches or educational technology. For example, King *et al.* (2023) mentioned that digital visualization can improve students' understanding of abstract concepts such as the Pythagorean Theorem, but its use is still limited in the classroom. Keerthigha and Singh (2023) also highlight the importance of teaching strategies that accommodate students' learning styles, but this research has not focused on implementation in the context of geometry

This research offers originality and novelty by integrating thematic analysis of students' difficulties patterns and their causative factors, including pedagogical and psychological aspects. By adding elements of educational technology and a contextual approach, the study not only identifies problems but also provides recommendations that teachers can directly implement. This is in contrast to previous studies that tended to only describe the type of difficulty students have without linking it to practical solutions (Nurhasanah *et al.*, 2023; Roesdiana, 2022; Amir, Malmia, & Taufik, 2021).

The research gap lies in the lack of an in-depth exploration of the relationship between student difficulties, their causative factors, and the implementation of effective

teaching strategies. This research will fill these gaps by presenting in-depth evidence-based findings, including difficulty identification, causation analysis, and innovative learning designs. For example, this study will explore the use of visual aids and digital technology to help students understand the relationships between the sides of a right triangle, as well as project-based teaching strategies to increase student engagement in learning (Pelletier *et al.*, 2022; Fianingrum *et al.*, 2023; Silwana & Widayanti. 2024; Vaghela & Parsana, 2024).

With this approach, research is expected to make a significant contribution to improving the quality of learning the Pythagorean Theorem, both in terms of theory and practice. The findings of this study are not only relevant to improve student understanding but can also be a reference for teachers in designing more innovative and effective learning strategies.

METHOD

This study uses a qualitative approach with a case study method to analyze students' difficulties in solving problems related to the Pythagorean Theorem. This method was chosen because it is able to provide an in-depth understanding of complex phenomena in a specific context, allowing for an in-depth exploration of the types of difficulties and their causative factors (Yin, 2018; Creswell, 2014; Cherkaoui & Oudrhough, 2024). Case studies have been widely used in educational research to understand the dynamics of learning as a whole, including interactions between students, teachers, and learning environments (Stake, 1995; Fahmi, 2024; Lubis & Saam, 2024).

The subjects of this study were thirty grade VIII students from SMP Negeri 8 Tasikmalaya, who were selected using the purposive sampling technique. This technique allows the selection of subjects based on specific criteria relevant to the research objectives (Patton, 2002). The selection of subjects was carried out based on the results of the initial test which showed the highest error rate in solving problems related to the Pythagorean Theorem. These criteria include conceptual errors, such as confusion in identifying the slant of a right triangle

(Khoerunnisa & Sari, 2021), procedural errors such as misapplying the Pythagorean formula (Indrawati *et al.*, 2024), and misinterpretation of the story, such as failing to transform contextual information into a relevant mathematical model (Meika *et al.*, 2022; Amir *et al.*, 2021; Maharani & Cesaria, 2024).

There are 3 main instruments used in this study. First, a written test designed to identify the type of student error on the concepts of the Pythagorean Theorem. This question only includes 4 short essays designed to measure students' understanding of concepts, application of procedures, and ability to solve story problems (Ritonga & Hasibuan, 2022; Rina & Bernard, 2021). Second, semi-structured interview guides are used to dig into students' in-depth understanding of the difficulties they face and the factors that cause them. The semi-structured interview format allows for flexible exploration of students' perspectives (Bryman, 2012). Third, observation sheets are used to record the interaction between students and teachers, the teaching strategies applied, and student participation during the learning process (Pelletier *et al.*, 2022).

Data was collected through three main techniques. First, a written test is done as a first step to map the student's difficulty level and identify error patterns. Second, in-depth interviews were conducted with the selected research subjects to further reveal their experiences in understanding and solving problems. These interviews provide insight into psychological and pedagogical factors that cannot be explained through written tests (Creswell, 2014; Meika *et al.*, 2022). Third, classroom observation is carried out to understand the dynamics of learning and interaction between teachers and students, as well as how teaching strategies affect students' understanding (Patton, 2002).

The collected data were analyzed using thematic analysis, which aims to identify the main patterns and themes of students' difficulties (Braun & Clarke, 2006). The analysis stage includes initial coding, in which relevant keywords or phrases are identified from test, interview, and observation data. Then, the data is categorized into main themes, such as

conceptual, procedural, and interpretive errors about the story (Khoerunnisa & Puspita Sari, 2021; Meika *et al.*, 2022). To ensure the validity of the findings, data triangulation was carried out by comparing test results, interviews, and observations to obtain consistent conclusions (Yin, 2018; Balbastre-Benavent *et al.*, 2024).

Through this approach, this research is expected to provide a comprehensive overview of the types of student difficulties, the factors that cause them, and relevant pedagogical solutions to improve the quality of learning of the Pythagorean Theorem.

RESULTS AND DISCUSSION

This section presents the results of the research systematically and in detail based on the research stages that have been set beforehand, and is directed to answer the formulation of the problem. The presentation of results was carried out by considering the integration of data from the three main instruments used in the research, namely written tests, in-depth interviews, and classroom observations. These three instruments are processed through a data triangulation process to ensure the validity and reliability of the findings. Each of the findings presented in the following subsection refers to empirical evidence obtained from all three data sources. For example, the identification of students' conceptual errors in determining the oblique side of a right-wing triangle is not only based on written test answers, but is also reinforced through in-depth interviews and observations of student behavior in the classroom. Thus, any conclusions drawn are based on cross-instrument confirmation, rather than just a single finding from a single method.

The presentation of the results was classified into four main categories of

difficulties experienced by students: (1) conceptual errors, (2) procedural errors, (3) difficulties in understanding and transforming story problems, and (4) anxiety in dealing with math problems. Each category is explained by including data from the test as an indicator of student performance, interview excerpts as a representation of students' personal understanding and experience, and observation notes as a context of learning behavior in the classroom. The structure of the results of this study prioritizes coherence between data, interpretation, and answers to problem formulations. Each aspect discussed not only describes the phenomenon of difficulties, but also provides an explanation of how and why these difficulties arise based on evidence obtained from the combination of the three research instruments. This kind of presentation not only strengthens the validity of the findings, but also shows that this research has been carried out thoroughly and in-depth according to the principles of qualitative studies that can be scientifically accounted for.

1. Conceptual Difficulties

Conceptual difficulties are the main problems found in this study. Students experience confusion in understanding the concept of the Pythagorean theorem, especially in identifying the sides of a right triangle. Some students are unable to distinguish between the oblique side and the upright side, leading to errors in the application of the formula. This can be seen in the written test, as many as 70% of students have difficulty identifying the oblique side of a right triangle. They don't understand that the slanted side is always facing right angles. The error can be seen in Figure 1 below.

Handwritten student work showing a calculation of the hypotenuse of a right triangle with legs 12 and 5. The student incorrectly identifies the hypotenuse as 19.106 instead of the correct value 13. The work includes the formula $c^2 = a^2 + b^2$ and a diagram of a right triangle with legs 12 and 5, and hypotenuse c .

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

$$c^2 = 12^2 + 5^2$$

$$c^2 = 144 + 25$$

$$c^2 = 169$$

$$c = \sqrt{169}$$

$$c = 13$$

Figure 1. Answers for Students Experiencing Conceptual Difficulties

To see the causes of mistakes made by students, the following is a transcript of the

interview between the researcher and the S1 participant.

Dialogue 1

.....	
Researchers	: "What is confusing you when working on this matter?" "That is why
S1	: "I don't know, sir. Which side is called the oblique side. Sometimes, I think all sides are the same."
Researchers	: "Then you know what a right angle is?"
S1	: "Yes, I know the right angle. But, I didn't realize that the slanted side was always facing the right angle."
Researchers	: "So, knowing that the slanted side is the longest side and faces the right angle, does this help you understand the problem?"
S1	: "Yes, now it's clearer. "I was wrong because I didn't know the term."
.....	

Based on the dialogue above, it appears that students understand some basic elements of triangles, such as right angles, but have not been able to relate these understandings to the position and names of the sides of the triangle. Ignorance of the term "oblique side" and the inability to relate it to the visual characteristics of a right triangle are the main obstacles in solving the problem

This shows that mastery of mathematical *vocabulary* plays an important role in building understanding of concepts. When learners do not understand terms such as "slanted", they will not be able to identify the right elements in a flat shape, which ultimately leads to the application of the wrong formula. In this case, conceptual problems are not only related to the understanding of forms, but also to the understanding of terminology and visual representations of the concept.

These findings are in line with the opinion of Khoerunnisa & Puspita Sari

(2021) that conceptual difficulties like this are often caused by teaching that focuses more on the application of formulas without ensuring a basic understanding of the underlying mathematical concepts. This is in accordance with the findings of Rina & Bernard (2021), who show that understanding basic concepts is essential before students can apply formulas correctly.

2. Procedural Difficulties

Procedural difficulties arise when students are unable to follow the correct steps in calculating or applying formulas. As many as 65% of learners are unable to follow the calculation steps correctly, especially when calculating squares and square roots. This procedural error is evident in problems involving large numbers or more complex operations. The error can be seen from the following image.

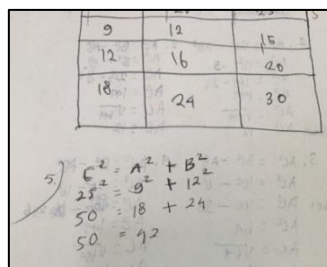


Figure 2. Answers for Students Experiencing Procedural Difficulties

To see the causes of mistakes made by students, the following is a transcript of the

interview between the researcher and the S2 participant.

Dialogue 2

.....		
Researchers	:	"What makes you confused when working on a problem like this?" <i>That is why</i>
S2	:	"Usually when you have to calculate the square, sir. If it's a big number, I'm often confused."
Researchers	:	"How do you calculate a number like 24 ² ?"
S2	:	"Sometimes I forget, sir. It should have been multiplied by 24 24, but I added 24 twice."×
Researchers	:	"After getting the squared result, what's the next step?"
S2	:	"I am often confused, sir, whether to count first or take the square root first."
Researchers	:	"What makes these steps confusing?"
S2	:	"The order, sir. I like to forget, which one should be counted first. Especially if the number is large, it becomes more difficult."
Researchers	:	"What do you usually do when you're confused by the steps?"
S2	:	"Sometimes I ask friends, sir. But if no one can help, I often just count."
.....		

Based on the dialogue above, it shows that the procedural difficulties of students are not only caused by a weak understanding of mathematical steps, but also due to the lack of a structured strategy in solving problems. Ignorance in basic procedures such as calculating squares and taking roots suggests that learners need intensive assistance in understanding the sequence of mathematical operations, particularly in the context of the Pythagorean theorem. In addition, dependence on friends and the tendency to "count origins" are indicators that participants do not yet have independent learning and are not used to the systematic thought process.

These findings are in line with the results of Indrawati *et al.* (2024) which mentions that this procedural error often occurs when students do not understand the correct sequence of mathematical operations,

such as calculating the squares of numbers before adding them. Research by Meika *et al.* (2022) also shows that students often rush in solving problems and do not double-check their calculations, which leads to errors in more complicated steps.

3. Difficulties in Interpreting Story Questions

Most students have difficulty interpreting stories related to the pythagoras theorem. This problem occurs because students have difficulty in converting information from story problems into mathematical forms that can be solved with formulas. As many as 60% of students have difficulty converting verbal information into mathematical models. These errors are often seen from their processing process, which can be seen in Figure 3 below.

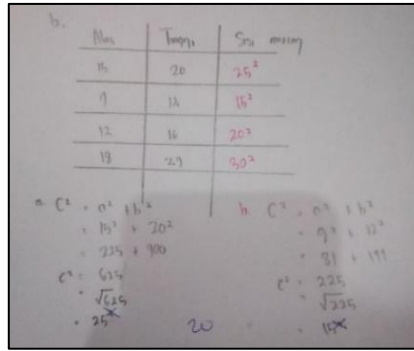


Figure 3. Answers for Students Who Have Difficulty in Interpreting Story Questions

To see the causes of mistakes made by students, the following is a transcript of the interview between the researcher and the S3 participant.

Dialogue 3

.....	
Researchers	: "Can you tell me what difficulties you had when trying to solve this skewed question?"
S3	: "I'm confused about how to make the table, sir. I don't know which number I should put in for the side of the slant and the other side."
Researchers	: "Can you show me the initial steps you took when creating the table?"
S3	: "I start by writing down the numbers of the questions, but sometimes I misdetermine which side is upright and which side is tilted."
Researchers	: "How do you prove the oblique side of a right triangle?"
S3	: "I know the formula, sir, but when multiplying and adding the squares, it is often wrong. Sometimes the numbers in the table don't match the end result either."
Researchers	: "What do you think will help you better understand how to make this table?"
S3	: "If there is a clear example or the steps are explained in more detail, I might be able to understand it more easily, sir."
Researchers	: "How do you feel when you try to solve a problem like this?"
S3	: "I was afraid of making mistakes again, so I was often confused about where to start when making the table."
.....	

In an interview, the S3 student revealed that he felt confused when faced with a story question that asked for spatial reasoning or analysis of the position of the sides of the triangle. He could not identify exactly which numbers were related to the upright, horizontal side, or slanted side. This is illustrated in his statement "I am confused about how to make the table, sir. I don't know which number I should put in for the side of the slant and the other side."

S3 also said that even though he knew the Pythagorean formula, he often made the wrong step when doing calculations because he did not understand the context of the

problem thoroughly, "I know the formula, sir, but when multiplying and adding the squares, it is often wrong. Sometimes the numbers in the table don't match the end result either." Furthermore, the student stated that the lack of concrete examples or gradual explanations made him hesitant to start solving the problem "if there is a clear example or the steps are explained in more detail, I might understand it more easily, sir." This statement indicates that students not only have difficulty in understanding the content of the problem, but also experience obstacles in relating contextual information to proper mathematical procedures. These weaknesses

have an impact on inaccuracies in choosing a settlement strategy, including in compiling diagrams, tables, or selecting appropriate operations.

These findings show that many students do not have adequate *mathematical literacy* skills, especially in recognizing important elements of the question text and relating them to their conceptual knowledge. This difficulty reflects the gap between the understanding of everyday language and formal mathematical representations.

This condition is supported by research by Rina & Bernard (2021) which found that many students have difficulty in converting verbal information into concrete mathematical forms. This is also discussed by Meika *et al.* (2022), which states that

teaching that does not pay attention to the understanding of story problems can hinder students' understanding of context-based mathematics material.

4. Difficulties Related to Math Anxiety

Mathematics anxiety is a factor that interferes with students' ability to solve math problems. Students who feel anxious often have difficulty concentrating and performing calculations accurately. The results of the observation showed that as many as 50% of students felt nervous about facing problems with large numbers, which shows how students' mistakes often arise due to their inability to think clearly under pressure. The following is picture 4 which shows students feeling discomfort in counting.

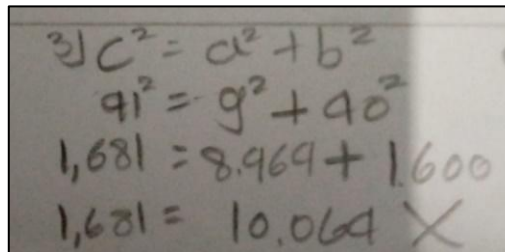


Figure 4. Answers for Students Who Have Difficulties Related to Math Anxiety

To see the causes of mistakes made by students, the following is a transcript of the

interview between the researcher and the S4 participant.

Dialogue 4

.....	
Researchers	: "How do you feel when you see a problem involving the Pythagorean Theorem?"
S4	: "I was immediately nervous, especially if there were big numbers or roots. I'm afraid of making mistakes, and it makes me unable to think clearly."
Researchers	: "Have you ever felt that anxiety is preventing you from solving problems?"
S4	: "Often. I know the formula, but when I'm nervous, I forget everything."
.....	

The results of the interview with S4 revealed that a nervous feeling arose that before the work process began, just because I saw a problem that was considered difficult "I immediately got nervous, especially if there was a large number or root. I'm afraid of making mistakes, and it makes me unable to think clearly." S4 also stated that the anxiety he experienced caused him to be unable to access the formulas or steps that he had actually learned. When in a stressful

state, learners tend to lose focus and make unnecessary mistakes. "Often. I know the formula, but when I'm nervous, I forget everything."

This description suggests that math anxiety not only impacts emotional aspects, but also affects cognitive functions such as working memory and concentration. Students who experience high anxiety tend to avoid problems that seem difficult, and when forced to work, they experience "*mental blocks*" that

cause difficulties in logical and systematic thinking.

In addition, observations showed that anxious students often showed passive behavior in class, such as not asking questions when having difficulties, lowering their heads when asked to answer, or rushing to solve problems without reading carefully. This reinforces the finding that anxiety not only comes from within students, but is also influenced by a less supportive learning environment.

These findings are consistent with the research results of Setiawan (2024) which states that students' critical and systematic thinking skills, which ultimately hinder them in solving mathematical problems effectively. These findings are consistent with studies by Rozgonjuk *et al.* (2020), which states that math anxiety often hinders students' ability to plan and execute appropriate problem-solving measures.

5. Factors Causing Difficulties

Based on the results of the study, the difficulties experienced by students are not only influenced by internal factors, such as understanding mathematical concepts and skills, but also by external factors related to the learning process in the classroom. Some of the key factors found include:

- a. **Monotonous Teaching Methods** Most of the students revealed that the teaching methods applied focused more on the delivery of theories and formulas without providing opportunities for students to explore or experience mathematics concepts. The results of the interviews showed that students felt bored with learning that was only centered on lectures or practice questions without any more interesting or interactive approach. Research by Fianingrum *et al.* (2023) also suggests that a more interactive and contextual approach to learning can improve students' understanding of mathematical concepts
- b. **Limited Use of Learning Media** Students also revealed that they had difficulty understanding Pythagorean Theorem due to the lack of use of interactive learning media. Most students feel that abstract mathematical concepts,

such as the Pythagorean Theorem, are easier to understand if they are presented in visual form or using technology. This is in accordance with research by Pelletier *et al.* (2022), which shows that the use of visual media can help students understand the relationship between mathematical elements more clearly.

- c. **Limitations of Technology Use** **Although** technology can play an important role in mathematics learning, this study found that the use of educational technology in the classroom is still limited. Students are not given the opportunity to use learning software or visual aids that can help them better understand concepts such as the Pythagorean Theorem (King *et al.*, 2023; Gu *et al.*, 2024; Shehzad & Charles., 2023).

The findings of this study show that students' difficulties in understanding the Pythagorean Theorem are caused by various factors, including conceptual, procedural, and interpreting problems in the story, as well as high math anxiety. Actionable solutions to address these difficulties include a more interactive and contextual approach to learning, the use of visual media, and the integration of educational technologies to support student understanding. With the application of these solutions, it is hoped that students' understanding of the Pythagorean Theorem can increase significantly.

CONCLUSION

Based on the results of analysis and discussion, it can be concluded that students experience four main types of difficulties in solving Pythagorean Theorem problems, namely conceptual errors, procedural errors, difficulties in interpreting story problems, and mathematical anxiety. These four difficulties do not stand alone, but are interrelated and strengthened by external factors such as monotonous teaching methods, lack of use of visual media and technology, and low motivation to learn.

This finding answers the formulation of the problem posed in this study, namely regarding the forms of difficulties faced by students and the factors behind them. This research implies the need to transform the

approach to mathematics learning in schools, by emphasizing the use of visual media, educational technology such as GeoGebra, and interactive learning strategies that suit students' learning styles. In addition, attention to the affective aspects of students such as math anxiety also needs to be integrated in learning planning.

However, this study has limitations. First, the study subjects included only students from one school, so the results could not necessarily be generalized to a wider population. Second, the approach used is qualitative so that it cannot provide quantitative information that describes the level of difficulty numerically. Follow-up research is recommended to involve more schools with a mixed approach to make the results more comprehensive and representative.

Based on these findings and limitations, the researcher recommends that teachers implement learning strategies that integrate visual media and digital technology consistently, as well as create a supportive learning environment to reduce math anxiety. In addition, training for teachers in designing learning approaches that are contextual and in accordance with the characteristics of students also needs to be encouraged. Further research can be focused on developing technology-based learning models specifically designed to address the types of difficulties that have been identified in this study.

ACKNOWLEDGMENT

The author expresses his deepest gratitude to Siliwangi University for the support and facilities provided during this research process. Thank you are also expressed to Mr. Dedi Muhtadi and Mrs. Vepi Apiati as supervisors who have provided guidance, direction, and very meaningful input in the preparation of this article. Thank you to SMP Negeri 8 Tasikmalaya, especially the teachers and students of grade VIII who have been willing to be the subject of research and provide data that is very important for the continuity of this study.

The author also thanks all parties who have assisted in the process of conducting the

research, including proofreaders who have reviewed the manuscript, typists who have assisted in document processing, and those who have provided materials or learning aids in supporting the implementation of this study. Without the contribution and support of these various parties, this research would not have been completed properly

AUTHOR'S CONTRIBUTION

Author One: Conceptualization, writing - original draft, editing, and visualization;

Author Two: Writing - review & editing, formal analysis, and methodology;

Author Three: Validation and supervision.

REFERENCES

- Amir, N. F., Malmia, W., & Taufik, T. (2021). Analisis Kemampuan Menyelesaikan Soal Cerita Matematika: Analysis of Ability to Solve Mathematics Story Problems. *Uniqbu Journal of Exact Sciences*, 2(2), 19-31. <https://doi.org/10.47323/ujes.v2i2.148>
- Balbastre-Benavent, F., Duque-Oliva, E. J., & Canet-Giner, M. T. (2024). Enhancing Management Research through Qualitative Methods. *Business Tec*, 18(3), 1-11. <https://doi.org/10.18845/te.v18i3.7282>
- Bryman, A. (2012). *Social research methods* (4th ed.). Oxford University Press. <https://doi.org/10.1891/9780826163561>
- Cherkaoui, A., & Oudrhough, Y. (2024). Case Study Methodology in Business Management: A Systematic Review. In *Applying Qualitative Research Methods to Management Science* (pp. 53-74). IGI Global. <https://doi.org/10.4018/979-8-3693-5543-5.ch003>
- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Sage Publications. <https://doi.org/10.1016/b978-0-323-96023-6.00095-6>

- Fahmi, J. A. (2024). Case Study Research in the Digital Age. *Qualitative Report*, 29(8). <https://doi.org/10.46743/2160-3715/2024.7563>
- Fianingrum, F., Novaliyosi, N., & Nindiasari, H. (2023). Independent Curriculum in Mathematics Learning. *Educational: Journal of Educational Sciences*, 5(1), 132–137. <https://doi.org/10.31004/edukatif.v5i1.4507>
- Gu, C., Peng, Y., Nastase, S. A., Mayer, R. E., & Li, P. (2024). Onscreen presence of instructors in video lectures affects learners' neural synchrony and visual attention during multimedia learning. *Proceedings of the National Academy of Sciences*, 121(12), e2309054121. <https://doi.org/10.1073/pnas.2309054121>
- Indrawati, N., Nuramilan, N., & Amin, N. (2024). Analysis of Students' Difficulties in Solving Pythagorean Theorem Problems. *Cognitive: HOTS Research Journal of Mathematics Education*, 4(1), 640–649. <https://doi.org/10.51574/kognitif.v4i1.1421>
- Keerthigha, C., & Singh, S. (2023). The effect of teaching style and academic motivation on student evaluation of teaching: Insights from social cognition. *Frontiers in Psychology*, 13, 1–7. <https://doi.org/10.3389/fpsyg.2022.1107375>
- Khoerunnisa, D., & Puspita Sari, I. (2021). Analysis of Students' Difficulties in Solving Pythagorean Theorem Problems. *Journal of Innovative Mathematical Learning*, 4(6), 1731–1742. <https://doi.org/10.22460/jpmi.v4i6.1731-1742>
- King, J., Marcus, T., & Markant, J. (2023). Individual differences in selective attention and engagement shape students' learning from visual cues and instructor presence during online lessons. *Scientific Reports*, 13(1), 1–14. <https://doi.org/10.1038/s41598-023-32069-7>
- Lubis, A., & Saam, Z. (2024, October). Perspective of Access Theory in the Context of Illegal Gold Mining: Insights from Kuantan Singingi Regency. In *Proceedings of International Conference on Science and Technology* (Vol. 2, No. 1, pp. 5–11). <https://doi.org/10.36378/internationalconferenceuniks.v2i1.3825>
- Maharani, Z., & Cesaria, A. (2024). Mathematical Problem-Solving Ability in Solving PLSV. *Journal of Mathematics Learning Innovation: PowerMathEdu*, 3(1), 29–36. <https://doi.org/10.31980/pme.v3i1.1440>
- Mayani, D. E. (2024). A Literature Study of Mathematical Anxiety Against Mathematics Learning and Explore the Student Mathematical Anxiety. *Mathematical Journal*, 3(1), 1–10. <https://doi.org/10.24036/rmj.v3i1.44>
- Meika, I., Berliana, R., & Sartika, N. S. (2022). Didactic Design for Concept Understanding of Junior High School (SMP) Students in Pythagorean Theorem Material. *Theorem*, 7(2), 411–424. <https://doi.org/http://dx.doi.org/10.25157/teorema.v7i2.8332>
- Nafisah, Z., Husna, L. D., & Khayroiyah, S. (2024). Analysis of Mathematic Problem-Solving Ability in Solving Pythagoras Theorem Problems. *Riemann: Research of Mathematics and Mathematics Education*, 6(2), 151–163. <https://doi.org/10.38114/akm0dp67>
- Nurhasanah, S., Nurcahyono, Andri, N., & Mulyanti, Y. (2023). Analysis of High School Students' Mathematical Problem-Solving Abilities in Solving SPLTV Story Problems. *Didactical Mathematics*, 5(2), 232–246. <https://doi.org/10.31949/dm.v5i2.5480>
- Nurmayunita, N., Soeprianto, H., Junaidi, J., & Patmi, S. (2024). Analysis of Students' Difficulties in Solving Story Problems in Pythagorean

- Theorem Material. *Journal of Mathematics Education and Application*, 4(1), 75-81. <https://doi.org/10.29303/griya.v4i1.432>
- Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). Sage Publications. <https://doi.org/10.1016/b978-0-323-85663-8.00010-6>
- Pelletier, K., McCormack, M., Reeves, J., Robert, J., Arbino, N., Al-Freih, W.M., Dickson-Deane, C., Guevara, C., Koster, L., Sanchez-Mendiola, M., Skallerup Bessette, L. & Stine, J. (2022). 2022 EDUCAUSE Horizon Report Teaching and Learning Edition (pp. 1-58. <https://www.learntechlib.org/p/221033/>.
- Reza, Lestari, Habibi, & Syaiful, B. (2024). Students' Perception of Mathematics Subjects (Case Study of Grade VI Students of SD Negeri 03 Gumay Ulu). *Journal of Educational Sciences*, 3(1), 21-28. <https://doi.org/10.58222/jurip.v3i1.777>
- Rina, R., & Bernard, M. (2021). Analysis of Mistakes of Junior High School Students in Grade VIII in Solving Problems on Pythagorean Theorem Material. *Journal of Scholars: Journal of Mathematics Education*, 5(3), 2836-2845. <https://doi.org/10.31004/cendekia.v5i3.870>
- Ritonga, E. D. S., & Hasibuan, L. R. (2022). Analysis of Students' Difficulties in Learning Mathematics Pythagorean Theorem Material Reviewed from Students' Learning Interests at SMP Negeri 1 Rantau Utara. *Journal of Scholars: Journal of Mathematics Education*, 6(2), 1449-1460. <https://doi.org/10.31004/cendekia.v6i2.1341>
- Roesdiana, L. (2022). Analysis of Mathematical Problem-Solving Ability of High School Students in Solving Three-Variable Linear Equation System Problems. *EduMatScience: Journal of Education, Mathematics and Science*, 6(2), 377-388. <https://doi.org/10.33541/edumatsains.v6i2.3615>
- Setiawan, A. (2024). Overcoming Students' Anxiety in Learning Mathematics. *Journal of Educational Innovation*, 7(1), 28-36. <https://doi.org/10.35141/jie.v7i1.1020>
- Shehzad, N., & Charles, T. (2023). Exploring the impact of instructor social presence on student engagement in online higher education. *Contemporary Educational Technology*, 15(4), ep484. <https://doi.org/10.30935/cedtech/13823>
- Sholeha, V. A., Risnawati, R., & Habibullah, H. (2021). An Analysis of Student Difficulties in Mathematics Learning in terms of Student Mathematical Connection Ability on Pythagoras Theorem. *Prisma Ciencias: Journal of the Study of Mathematics and Science Science and Learning IKIP Mataram*, 9(1), 12-19. <https://doi.org/10.33394/j-ps.v9i1.3510>
- Silwana, A., & Widayanti, E. (2024). The Urgency Of Critical Thinking Disposition In Mathematics Learning In The Independent Curriculum. *Lebesgue Journal: Scientific Journal of Mathematics, Mathematics and Statistics Education*, 5(2), 1295-1303. <https://doi.org/10.46306/lb.v5i2.716>
- Stake, R. E. (1995). *The art of case study research*. Sage Publications. <https://doi.org/10.1016/b978-0-12-818630-5.11010-3>
- Umar, Irawati, T. N., & Siskawati, F. S. (2021). The Application of the Group Investigation Learning Model Based on Realistic Mathematic Education to Improve Mathematics Learning Activities and Outcomes. *Journal of Axioma: Journal of Mathematics and Learning*, 6(2), 87-95.

- <https://doi.org/10.36835/axi.v6i2.1049>
- Vaghela, V. S., & Parsana, F. (2024). Teaching and Learning: Fostering Student Engagement, Critical Thinking, and Lifelong Learning Skills. *Educational Administration: Theory and Practice*, 30(6(S)), 66-73. [https://doi.org/10.53555/kuey.v30i6\(s\).5324](https://doi.org/10.53555/kuey.v30i6(s).5324).
- Viera, C. A. (2023). Case Study As A Qualitative Research Methodology. *Performance Improvement Journal*, 62(4), 125-129. <https://doi.org/10.56811/pfi-23-0005>
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage Publications. <https://doi.org/10.4135/9781529604467>