




Exploring the Mathematical Conceptual Understanding of Students Using AI Chatbots in Pythagorean Theorem Material

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| Article Info | Abstract |
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| Received March 30, 2026 | The rapid development of artificial intelligence (AI) in education has created new opportunities to enhance students' mathematical conceptual understanding and support more personalized learning experiences. This study aims to explore students' mathematical conceptual understanding when using AI chatbots in learning the Pythagorean Theorem. This study employs a descriptive qualitative approach, involving eighth-grade junior high school students selected through purposive sampling based on their level of conceptual understanding. Data were collected through a perspective questionnaire, an essay-based test, and semi-structured interviews, and analyzed using data reduction, data presentation, and conclusion drawing. The findings reveal that students were able to meet all indicators of mathematical conceptual understanding, with AI helping them understand definitions, visualize geometric relationships, obtain immediate feedback, and recognize real-world applications of the Pythagorean Theorem. However, students still face difficulties in meeting some of the indicators of mathematical conceptual understanding in the Pythagorean theorem, which were influenced by a tendency to rush and the suboptimal use of AI features. In conclusion, although AI can effectively support conceptual understanding, its integration in learning should be accompanied by teacher guidance to foster metacognitive awareness and deeper, more reflective learning. |
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| Keywords | |
| AI Chatbots; Mathematical Conceptual Understanding; Mathematics Learning; Pythagorean Theorem. | |

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INTRODUCTION

Mathematical conceptual understanding is a fundamental goal in mathematics learning, as it enables students to connect ideas, interpret relationships, and apply knowledge in various contexts (Kholid et al., 2021). According to Skemp (1976), conceptual understanding involves knowing both what to do and why. Mathematical understanding can be divided into two types, which are instrumental understanding and relational understanding. Instrumental understanding refers to a student's ability to use mathematical procedures without an understanding of the underlying reasons (rules without reasons). Meanwhile, relational understanding refers to the ability to apply mathematical procedures supported by connections

between relevant concepts, accompanied by a deep understanding of the reasons behind the use of those procedures (knowing what to do and why). Different from Skemp (1976) and Hiebert and Carpenter (1992) has their own theory about conceptual understanding. They emphasize that it is characterized by a network of connected knowledge.

Mathematics education in the modern era faces a variety of complex challenges. (Buyung et al., 2022) state that there are still a number of obstacles hindering the optimal achievement of mathematics learning objectives. One of the fundamental issues highlighted by Sucipto and Firmansyah (2021) is the widespread perception that mathematics is a difficult subject that tends to instill fear (Azizah & Abadi, 2022). This leads to students avoiding math and results in their poor mathematical conceptual understanding (Diana et al., 2020). Without strong conceptual understanding, students tend to have difficulty grasping a mathematical concept (Umam & Zulkarnaen, 2022).

One mathematical topic that requires strong conceptual understanding is the Pythagorean theorem. Although students are often able to recall and apply the formula, the errors identified included students' inability to determine the length of a triangle's sides due to a lack of understanding of square root operations, difficulty in understanding the problem statements, a tendency to answer without following the correct concepts and steps due to rushing, a lack of precision in calculations, and errors in the problem-solving process that led to incorrect final answers (Febiana et al., 2025).

Advances in digital technology have fundamentally brought about many significant changes in the educational landscape (Rusman et al., 2024; Saugadi et al., 2025; Widodo et al., 2024). As stated by Harahap and Napitupulu (2023), these technological advances can open up great opportunities to expand access and improve the quality of learning, but on the other hand, they can also create new challenges that must be addressed. Furthermore, they explain that technology encourages the creation of a more interactive and collaborative teaching and learning process, which in turn can increase student motivation and active engagement.

Artificial intelligence (AI) is one example of technological development. Of the many types of AI, AI chatbots are the most commonly used in education, especially by students for learning. The findings of Labadze et al. (2023) reveal that AI-based systems, especially chatbots, have the capacity to provide quick responses through instant feedback, explanations of material, additional learning resources, and automatic adjustment of question difficulty levels. They highlight ChatGPT as one of the most advanced AI chatbots whose capabilities have amazed the world. This capability is reinforced by research by Wardat et al. (2023), which states that educators can utilize ChatGPT to design relevant and personalized learning materials, thereby increasing student engagement and academic achievement.

In the context of mathematics education, AI technology offers various digital features that support the teaching and learning process. Visualization of abstract concepts, interactive simulations, and adaptive learning systems are some examples of features that aim to improve students' understanding of the material (Wulandari et al., 2025). The main advantage of these features is their ability to create a personalized learning experience. As explained by Auna et al. (2024), AI allows students to learn at their own pace and according to their individual needs, so that

the process of mastering mathematical concepts can take place more efficiently and optimally.

Based on observations in class VIII A at Adhyaksa 1 Junior High School in Jambi City, students gained mathematical concepts from teachers when teaching in class using printed books. Furthermore, to find out the students' views on the use of artificial intelligence in learning mathematics, the researcher interviewed two female students and two male students in the eighth grade of junior high school. The two girls said that they used AI in learning mathematics to gain additional understanding of a mathematical subject. They added that they would use AI if the concepts or questions were too difficult to understand. In contrast to the answers given by the two male students, they use AI in learning, but not in learning mathematics. They believe that mathematics must be learned gradually through books or taught directly by expert tutors, not just by looking at instant answers.

This confirms the statement that not all AI applications automatically enhance conceptual understanding, as students tend to rely on instant answers without engaging in deep thinking (Gonsalves, 2026). On the other hand, recent studies suggest that artificial intelligence, particularly AI chatbots, has the potential to support students' conceptual understanding through adaptive explanations and rapid, personalized feedback (Kasneci et al., 2023; Labadze et al., 2023). By providing immediate responses and adjusting explanations based on students' needs, AI systems can facilitate more meaningful and individualized learning experiences (Zawacki-Richter et al., 2019). This indicates a connection between the use of AI and students' mathematical conceptual understanding, particularly in how students construct, interpret, and apply the concepts they have learned. However, this relationship has not yet been fully understood in depth, especially in the context of specific topics such as the Pythagorean Theorem, which requires relational understanding and the ability to connect various mathematical representations. Therefore, there is a research gap in examining how the use of AI actually influences students' levels of mathematical conceptual understanding. This study aims to fill this gap by exploring the mathematical conceptual understanding of students using AI chatbot in Pythagorean Theorem.

RESEARCH METHODS

This study adopts a descriptive qualitative approach aimed at exploring the mathematical conceptual understanding of eighth-grade students at Adhyaksa 1 Junior High School in Jambi City on the Pythagorean Theorem, particularly in the context of using the ChatGPT AI chatbot as a learning tool. It is designed as an exploratory qualitative study employing a case study approach, with a focus on an in-depth analysis of a student who demonstrated the highest level of mathematical conceptual understanding. The research subject was selected through purposive sampling, beginning with the distribution of perspective questionnaires to 16 students to identify their perspective of AI use in learning mathematics.

Data collection was carried out in three stages using different instruments. The first stage involved administering a perspective questionnaire to explore students' views on the use of AI in learning mathematics, both independently and in classroom settings. The questionnaire included questions about whether students used AI when studying mathematics, their perceptions of its usefulness, how they

constructed prompts to solve mathematical problems, their behavior while using AI, and their suggestions for guidelines if ChatGPT were to be integrated into classroom learning. Based on the results of the questionnaire, 10 students who met the predetermined criteria, namely those who actively used AI as a learning tool in mathematics, were selected as the main participants.

Second, a mathematical conceptual understanding test consisting of essay questions on the Pythagorean Theorem was administered to the 10 selected participants to determine their level of conceptual understanding based on predetermined indicators (see Table 1). After the responses were assessed, students were categorized into high, medium, and low levels of mathematical understanding. In accordance with the exploratory qualitative design employing a case study approach, this study focuses on one student who demonstrated the highest level of conceptual understanding. This selection enabled an in-depth exploration of the student's reasoning processes and the role of AI in supporting conceptual understanding.

Table 1. Indicators of Mathematical Concept Understanding

| Indicators | Description of the Pythagorean Theorem material |
|---|---|
| 1. Reiterating a concept | Students can explain the Pythagorean Theorem in their own words without simply repeating the definition from the book. |
| 2. Classifying objects according to specific characteristics using concepts | Students can determine which triangle is a right triangle based on the length of its sides. |
| 3. Providing examples and non-examples of concepts. | Students can create their own examples of right triangles and non-examples (triangles that are not right triangles) along with explanations. |
| 4. Presenting concepts in various mathematical representations. | Students can present the Pythagorean theorem in various forms, such as formulas, pictures, square area diagrams, tables, and even story problems. |
| 5. Developing necessary or sufficient conditions for concepts. | Students can explain the necessary or sufficient conditions for a right triangle. |
| 6. Using specific procedures or operations. | Students can explain the necessary or sufficient conditions for a right triangle. |
| 7. Applying concepts or problem-solving algorithms. | Students can apply the Pythagorean Theorem to solve complex contextual problems. |

Third, semi-structured interviews were conducted to clarify the student's responses to both the questionnaire and the test, as well as to further examine the student's thought processes and the influence of AI in shaping their understanding.

The collected data were analyzed qualitatively through the stages of data reduction, data presentation, and conclusion drawing. The questionnaire data were reduced by grouping students' responses according to their use of AI. Meanwhile, the test data were analyzed based on the attainment of mathematical conceptual

understanding indicators adapted from Meidianti et al. (2022), as adjusted by the researchers.

The data were further categorized into low, medium, and high levels of mathematical conceptual understanding based on the established indicators. In addition, the interview data were transcribed and systematically coded to identify patterns in students' thinking processes and to examine the contribution of AI to their conceptual understanding. To ensure the validity of the findings, triangulation across instruments was employed by comparing the results of the questionnaires, tests, and interviews, thereby enhancing the credibility and comprehensiveness of the data analysis.

RESEARCH RESULTS

A questionnaire on students' perspectives regarding the use of AI in mathematics learning was administered to 16 students in class VIII A at Adhyaksa 1 Junior High School in Jambi City. The results indicated that 14 students reported using AI in learning mathematics, while 2 students did not. Among the 14 students, 10 specifically reported using the ChatGPT AI chatbot as a learning tool. These 10 students were then considered for further analysis.

Subsequently, a mathematical conceptual understanding test on the Pythagorean Theorem was administered, and students' responses were categorized into high, medium, and low levels based on predetermined indicators. In line with the exploratory qualitative design employing a case study approach, this study does not aim to represent all categories but rather to provide an in-depth understanding of a specific case. Therefore, one student, coded as R04, was purposively selected as the main subject because they demonstrated the highest level of mathematical conceptual understanding and consistently used ChatGPT in their learning process. This selection was intended to explore in detail how AI supports the development of conceptual understanding under optimal conditions.

While the findings are based on a single subject, this is consistent with the case study approach, which prioritizes depth of analysis over generalizability in order to capture nuanced processes of students' conceptual understanding.

The following section presents the results of R04's responses based on the indicators of mathematical conceptual understanding, along with an integrated analysis of questionnaire, test, and interview data.

Reiterating a Concept

In Figure 1, R04 demonstrates the ability to fulfill the first indicator of mathematical conceptual understanding, namely reiterating the concept. Based on the written response, R04 defines the Pythagorean Theorem as "a formula used to find the length of the sides of a right triangle" and provides the formula $c^2=a^2+b^2$. This answer reflects a correct basic understanding of the concept, as it captures the essential idea of the relationship between the sides of a right triangle. Although the definition is still relatively procedural and not fully elaborated, it can be considered appropriate and aligned with the concept of the Pythagorean Theorem.

This finding is consistent with the questionnaire results, which indicate that R04 is one of the students who actively uses AI, particularly the ChatGPT chatbot, in learning mathematics. The use of AI appears to support R04 in recalling and

restating fundamental concepts. Furthermore, based on the interview, R04 was able to verbally explain the concept without referring to the written answer, stating, “I just know the formula, which is $c^2=a^2+b^2$ ”. This suggests that the subject has internalized the formula as part of their conceptual understanding.

C. Adalah rumus yang digunakan untuk mencari panjang sisi pada segitiga siku-siku \rightarrow rumusnya
 $(c^2 = a^2 + b^2)$

Is a formula used to find the length of the sides of a right triangle. \rightarrow The formula is

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

Figure 1. Subject's Answer on Indicator 1

In addition, R04 acknowledged the role of AI in supporting their learning process, stating, “Because I had previously fallen behind in the lessons, I studied the Pythagorean Theorem material with the help of AI.” This indicates that AI contributed as a supplementary learning resource, helping the subject catch up and understand the basic concept of the Pythagorean Theorem.

Classifying Objects According to Specific Characteristics Using Concepts

In Figure 2, R04 demonstrates the ability to fulfill the indicator of applying concepts to determine whether a triangle is a right triangle, accompanied by appropriate reasoning. Based on the written response, R04 shows the calculation ($6^2+8^2=36+64=100$), which reflects the use of the Pythagorean Theorem. Through this process, subject is able to verify that the given side lengths satisfy the condition of a right triangle, indicating an understanding of how the concept can be applied to justify a mathematical statement. This finding is consistent with the test results, which show that R04 can correctly apply the relationship between the sides of a right triangle. Furthermore, the interview data support this result. R04 explained, “Since $6^2+8^2=100$ and $10^2=100$, they can be equated, so it can form a right triangle.” This explanation indicates that the subject not only performs the procedure correctly but also understands the reasoning behind it.

F. diketahui : $6^2 + 8^2 = 36 + 64 = 100$
 $10^2 = 100$
 Karena kedua hasilnya sama papan tersebut dapat membentuk segitiga siku-siku

known: $6^2 + 8^2 = 36 + 64 = 100$
 $10^2 = 100$

since both results are the same, the boards can form a right triangle

Figure 2. Subject's Answer on Indicator 2

In addition, based on the interview, R04 stated that no external resources, including AI, were used in answering this question. This suggests that the subject’s

understanding in this case was constructed independently. Therefore, the result reflects R04's own conceptual understanding without direct assistance from AI, highlighting that not all demonstrated understanding is necessarily influenced by the use of AI.

Providing Examples and Non-Examples of Concepts

In Figure 3, R04 demonstrates the ability to fulfill the indicator of providing examples and non-examples of right triangles based on the Pythagorean Theorem. As shown in the figure, R04 provides an example with side lengths of 3 cm, 4 cm, and 5 cm, and a non-example with side lengths of 5 cm, 6 cm, and 7 cm. The subject also includes explanations, such as "because $3^2+4^2=5^2$ " and "does not satisfy the Pythagorean Theorem formula." These responses indicate that R04 understands the distinguishing characteristics between examples and non-examples by correctly applying the underlying concept.

| | |
|--|---|
| e. • Segitiga siku ² (sisi 3cm, 4cm dan 5cm) karena $3^2 + 4^2 = 5^2$ | • Segitiga bukan siku ² (sisi 5cm, 6cm, dan 7cm) ↳ tidak memenuhi rumus teorema Pythagoras |
| • right triangle (3cm, 4cm and 5cm sides) because $3^2 + 4^2 = 5^2$ | • non right triangle (5cm, 6cm and 7cm sides) does not satisfy Pythagorean theorem formula |

Figure 3. Subject's Answer on Indicator 3

Furthermore, the interview data reveal that AI played a limited role in this understanding. R04 stated, "I used ChatGPT to help me understand more about examples and non-examples, but the ones I wrote were entirely from my own thinking." This suggests that, while AI contributed as a supplementary resource, the subject was able to independently construct and apply the concept in identifying appropriate examples and non-examples.

Presenting Concepts in Various Mathematical Representations

Based on Figure 4, R04 demonstrates the ability to identify and restate the known information from the problem, including the base (9 m), height (12 m), and hypotenuse (15 m), and to describe the position of the right angle. The subject states that "the right angle is at the intersection of the floor and the wall," which reflects an understanding of the contextual situation presented in the problem. This indicates that R04 is able to interpret the problem and translate it into a verbal representation that aligns with the given information. However, although the subject shows an understanding of the situation, R04 does not present a visual representation in the form of a sketch, which is part of the indicator of expressing concepts in multiple mathematical representations. This suggests that the subject's representation remains limited to verbal and symbolic forms.

However, based on the interview results, R04 acknowledged this limitation, stating, "I know how to sketch it, but I did not realize that the question asked for a sketch of the right triangle." This response indicates that the omission was not due to a lack of conceptual understanding, but rather a lack of careful attention to the

instructions. Therefore, while R04 demonstrates partial fulfillment of the indicator, the representation is not yet complete across all expected forms.

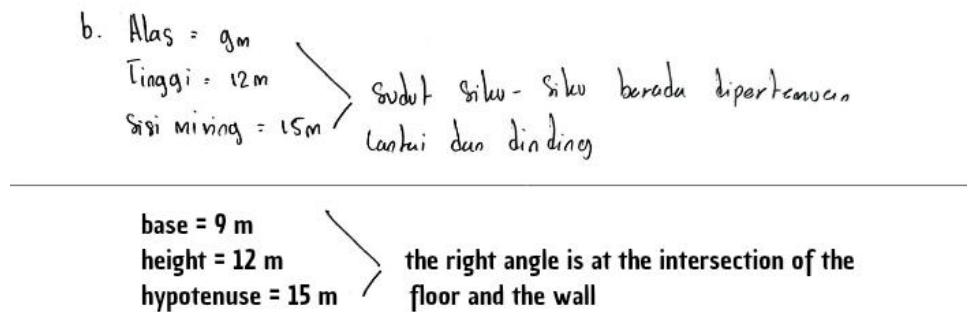


Figure 4. Subject's Answer on Indicator 4

Developing Necessary or Sufficient Conditions for Concepts

Based on Figure 5, R04 demonstrates the ability to state conditions related to the concept of a right triangle in accordance with the Pythagorean Theorem, such as the presence of a 90° angle and the relationship $c^2 = a^2 + b^2$. These statements are conceptually correct and aligned with the formal definition. However, R04 is not yet able to distinguish between necessary and sufficient conditions, as the responses present these conditions without clarifying their logical roles. This indicates a limited understanding of the conceptual structure, particularly in differentiating conditions that must be satisfied from those that are sufficient to establish the concept.

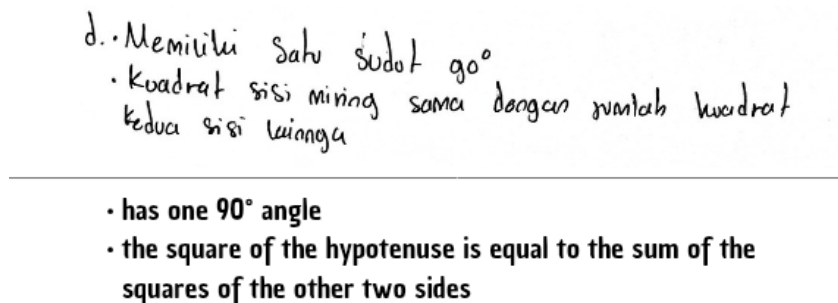


Figure 5. Subject's Answer on Indicator 5

This limitation is supported by the interview results, where R04 was unable to explain the distinction and relied on recalling learned statements. The subject noted, "I learned with ChatGPT's help," and justified the answers by stating that they were also found in a textbook. This suggests that the understanding remains procedural and dependent on external sources, rather than reflecting a deeper, relational comprehension.

Using Specific Procedures or Operations

Based on Figure 6, R04 demonstrates the ability to apply specific procedures or operations in solving the problem. The subject begins by identifying that the situation described forms a right triangle, indicating an initial understanding of the

problem context. R04 then systematically writes down the known information, including the distance from the ladder's foot to the wall (9 m), the height from the floor (12 m), and the length of the ladder as the hypotenuse. Furthermore, R04 applies the Pythagorean Theorem correctly by substituting the known values into the formula $c^2 = a^2 + b^2$, resulting in $c^2 = 9^2 + 12^2 = 81 + 144 = 225$, and concluding that $c = 15$ cm. These steps indicate that the subject follows a clear, sequential, and structured procedure rather than directly stating the final answer. This reflects a good level of procedural understanding in applying the concept to solve a contextual problem.

| | |
|---|--|
| <p>a. Situasi tersebut Membentuk Segitiga siku-siku Jarak ke dinding : 9m Tinggi lampu dari lantai : 12m Panjang tangga : sisi miring</p> <p>Teorema pythagoras : (panjang tangga Andi 15m) $c^2 = a^2 + b^2$ $= 9^2 + 12^2$ $= 81 + 144$ $= 225$ $= 15$</p> | <p>the situation forms a right triangle distance from the ladder foot to the wall = 9 m the height of the lamp from the floor = 12 m the length of the ladder = hypotenuse</p> <p>Pythagorean Theorem = (the length of Andi's ladder is 15 m)</p> $c^2 = a^2 + b^2$ $= 9^2 + 12^2$ $= 81 + 144$ $= 225$ $= 15$ |
|---|--|

Figure 6. Subject's Answer on Indicator 6

This finding is supported by the interview results, in which R04 explained how the information was identified from the problem, stating, "I looked at the problem, such as the distance from the ladder's foot to the wall and the height of the lamp from the floor." When asked about the source of this understanding, R04 responded, "It was explained by my math teacher in class on how to solve it." This suggests that the subject's procedural knowledge was primarily developed through classroom instruction and prior exposure to similar problems.

Applying Concepts or Problem-Solving Algorithms

In Figure 7, R04 demonstrates the ability to apply the Pythagorean Theorem to a real-life context. The subject provides an example, stating that it "can be used to determine the length of a ladder needed to reach the roof of a house at a certain distance." This response indicates that R04 understands how the concept of a right triangle can be applied in everyday situations, particularly by recognizing the ladder as the hypotenuse and the wall and ground as the perpendicular sides.

9. dapat digunakan untuk Menentukan panjang tangga yang diperlukan agar mencapai atap rumah dengan jarak tertentu

can be used to determine the length of ladder needed to reach the roof of a house at a certain distance

Figure 7. Subject's Answer on Indicator 7

This finding suggests that R04 is able to connect abstract mathematical concepts to practical applications, reflecting an understanding beyond purely symbolic

manipulation. Furthermore, based on the interview results, R04 explained that this example was obtained from a book she had previously read. This indicates that the subject's ability to apply the concept is supported by prior exposure to contextual problems, which helps reinforce the relevance of the Pythagorean Theorem in real-world situations.

DISCUSSION

The findings of this study indicate that R04 demonstrates overall competence in fulfilling the indicators of mathematical conceptual understanding on the Pythagorean Theorem, although the depth of understanding varies across indicators. In several aspects, R04 shows the ability to restate concepts, apply procedures, and connect mathematical ideas to real-life contexts. However, limitations remain in terms of deeper conceptual reasoning and metacognitive awareness. The subject's answers demonstrate a good mastery almost all of mathematical concept comprehension indicators, in accordance with the indicators used in the study by Meidianti et al. (2022). These findings are also supported by the research of Putri and Nasution (2023), which states that students with good mathematical concept comprehension abilities enable students to relate and apply that understanding in real-life contexts outside the classroom, which in turn strengthens their capabilities in solving various problems.

The subject was able to fulfill the first indicator, which was to restate a concept. This was evident from the subject's written answer in Figure 1, where she wrote down the definition of the Pythagorean Theorem correctly and in her own words. The subject is able to mention the formula and explain its basic meaning, indicating an understanding of fundamental concepts. However, the explanation provided remains relatively simple, indicating that the understanding is still at a basic level. Based on the interview, the subject explained that she used AI to find alternative explanations when she had previously fallen behind in the lessons. AI helped her find simpler and easier-to-remember definitions. This ability is in line with the research by Chimmalee and Anupan (2022), which states that a technology-based learning environment can improve students' conceptual understanding through access to various interactive learning resources.

In the second indicator, subjects can classify objects according to certain properties in accordance with the concept. As shown in Figure 2, she was able to identify and classify known sides (6 m, 8 m, and 10 m) as right triangles based on the concept. In the interview, the subject also explained that her understanding was obtained from what she remembered about the material and then adjusted to what was known from the question. The subject also stated that the role of AI was not very significant in this indicator. This indicates that the subject possesses a spirit of self-directed learning. In a study by Nugroho et al. (2025) it is stated that self-directed learning is one of the key competencies that can help students tackle learning challenges in the digital age, where instant answers are readily available.

The third indicator, which is to provide examples and non-examples of the concept, was also well fulfilled. In Figure 3, the subject provided examples of right triangles and non-right triangles in the form of known sides, then applied the Pythagorean Theorem concept so that it could be stated whether the example was a right triangle or not. Based on the interview, the subject admitted to frequently

practicing similar problems that were personally recommended by ChatGPT AI based on their ability level. This is in line with the research by Lee et al. (2025), which shows that real-time personal feedback from technology can deepen students' mathematical conceptual understanding.

In the fourth indicator, which is presenting concepts in various forms of mathematical representation, the subject was actually able to explain the steps to solve the story problem by converting it into a mathematical model and mentioning the need to make a sketch. However, as shown in Figure 4, the subject forgot to draw right-angled triangle sketch requested in the question due to carelessness. In the study by Mafruhah and Muchyidin (2020), this error is referred to as "omitted data", which is an errors based on Watson's criteria. Another contributing factor is that students tend to rush and are not careful when working on the problems. Based on the interview, the subject admitted that she was in a hurry and focused on the calculations, thus missing the instruction to make a right triangle sketch.

In the fifth indicator, R04 is able to state relevant conditions correctly but is unable to distinguish between necessary and sufficient conditions or explain their logical relationships. This indicates that the subject's understanding remains at a procedural or recall level rather than a relational level. Such findings are consistent with previous studies showing that subjects often struggle with higher-order reasoning and the structural aspects of mathematical concepts (Zendrato et al., 2025). R04 also explained in her interview that AI often provides her with general concepts without explaining whether they are necessary or sufficient conditions for the concept. This uncertainty indicates that the use of AI needs to be balanced with teacher guidance to achieve a higher level of understanding. This finding reinforces the statement by Giriansyah et al. (2023) that students with instrumental understanding are able to use formulas but do not necessarily understand the relationship between concepts in depth.

For the sixth indicator, the subject was able to use certain procedures or operations. This was a prove that R04 demonstrates a clear and structured problem-solving process. The subject is able to identify known information, apply the appropriate formula, and arrive at the correct solution systematically. This reflects strong procedural understanding, which is often developed through formal instruction and practice. It Based on the interview, the subject explained that she acquired this procedural understanding from what was often taught by teachers at school. However, she also admitted that AI still played a role in her procedural understanding. This shows that the subject has good procedural skills, which were acquired from what was taught by teachers, supported by the habit of practicing and verifying her answers through technology.

Finally, on the seventh indicator, which is applying problem-solving concepts or algorithms, the subject also showed satisfactory results. In Figure 7, the subject was able to apply the concept contextually and relate it to the application of the Pythagorean Theorem in everyday life. In the interview, the subject said that she got examples of applying the concept from a book she had studied, so AI did not play a significant role in this understanding.

Overall, the subjects in this study were able to meet all concept comprehension indicators well. The use of AI in learning made a positive contribution, especially in helping subjects understand definitions, visualize concepts, and practice questions with instant feedback. However, several inhibiting factors were found,

such as a lack of precision and uncertainty in distinguishing between necessary and sufficient conditions. This shows that technology is only a tool; strong conceptual mastery and good metacognitive habits still need to be developed through teacher guidance and student awareness to not just passively receive information.

CONCLUSION

This study concludes that, based on an in-depth analysis of subject R04, the use of AI in mathematics learning can support several indicators of conceptual understanding of the Pythagorean Theorem, including restating concepts, classifying objects, providing examples and non-examples, representing concepts, and applying procedures. However, difficulties remain in articulating necessary and sufficient conditions, suggesting that AI support does not equally facilitate all dimensions of conceptual understanding. These findings should not be generalized, but rather interpreted as a representation of an individual learning pattern in interacting with AI.

The study contributes to theory by suggesting that AI-assisted mathematics learning can be viewed as a guided cognitive partnership, where understanding emerges from the interaction between AI affordances and learners' self-regulation. In terms of AI design, the findings indicate the need for systems that better scaffold higher-order reasoning, particularly in supporting relational understanding. Practically, educators should guide students to use AI more reflectively, while future research should involve more participants and explore broader cognitive aspects to strengthen the generalizability of these insights.

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