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Analysis of Students' Mathematical Semiotic Representation Ability in Terms of Self-Confidence

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ABSTRACT

Mathematical semiotic representation ability plays an important role in helping students understand and solve mathematical problems. However, differences in students' self-confidence may influence how they construct mathematical representations. This study aimed to analyze students' mathematical semiotic representation abilities in terms of high, medium, and low levels of self-confidence. This research employed a descriptive qualitative approach involving eighth-grade students of SMP Negeri 19 Tasikmalaya. Three students representing high, medium, and low levels of self-confidence were purposively selected based on the results of the self-confidence questionnaire, the mathematical semiotic representation ability test, and semi-structured interviews. The research instruments consisted of a self-confidence questionnaire and a mathematical semiotic representation ability test developed based on Peirce's semiotic indicators, namely iconic (visual representation), symbolic (the use of mathematical symbols and formulas), and indexical (explaining the relationship between the solution and the problem context). Data were collected through self-confidence questionnaires, written tests, and semi-structured interviews, then analyzed through data reduction, data display, and conclusion drawing. The findings showed that the student with high self-confidence was able to represent problem situations through appropriate visual representations (iconic), use mathematical symbols and formulas correctly to solve the problem (symbolic), and explain the relationship between the solution and the problem context logically (indexical). The student with medium self-confidence also demonstrated all three indicators but showed inaccuracies in calculations and hesitation when explaining the obtained results. Meanwhile, the student with low self-confidence was able to construct visual and symbolic representations but experienced difficulties in explaining the relationship between the obtained solution and the context of the problem, indicating that the indexical representation was not fully achieved.

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Introduction

Mathematical representation ability is an essential competency that supports students in understanding concepts and solving mathematical problems effectively. Mathematical representation enables students to express mathematical ideas in various forms, such as visual, symbolic, and verbal representations (Sabirin, 2014). According to the National Council of Teachers of Mathematics (NCTM), mathematical representation involves expressing mathematical ideas through diagrams, symbols, tables, graphs, equations, or other forms that facilitate problem solving (Lestari et al., 2020). However, mathematical representation generally emphasizes the forms used to express mathematical ideas, whereas mathematical semiotic representation focuses on how these representations function as signs that convey mathematical meaning. From a semiotic perspective, students are expected not only to produce representations but also to interpret and relate them to the underlying mathematical concepts. However, previous studies have shown that students' mathematical representation abilities are still not optimally developed. Student often experience difficulties in transforming problems into appropriate representations, such as diagrams, mathematical models, or symbolic forms (Sutrisno et al., 2019). This condition indicates that mathematics learning has not fully supported the comprehensive approach to examine this issue.

One approach that can be used to analyze mathematical representation is the semiotic perspective. According to Peirce (1960) , signs are classified into three categories: icon, symbol, and indexical. Icons represent objects through visual resemblance, symbols represent mathematical ideas through conventional signs such as mathematical notation and formulas, while indexes indicate logical or causal relationships between representations and the concepts they represent (Chandler, 2007). In mathematics learning, these categories are particularly relevant because students are required to construct visual representations of problem situations, apply mathematical symbols and formulas appropriately, and explain the relationships between mathematical procedures and the problem context. Therefore, Peirce's semiotic framework provides an appropriate analytical lens for examining students' mathematical representations when solving Pythagorean theorem problems. This view is consistent with Iori (2017), who emphasized that students' mathematical understanding develops through the coordination and interpretation of semiotic representations during learning. Furthermore, Ferretti et al., (2024) emphasized that students' mathematical understanding depends on their ability to manage and coordinate multiple semiotic representations. Therefore, examining students' semiotic representations provides valuable information about how mathematical ideas are interpreted and communicated during problem solving.

Previous studies have also demonstrated the importance of mathematical semiotic representation in mathematics learning. Choiriyaza et al., (2021) reported that learning activities designed to encourage students to construct, interpret, and communicate mathematical ideas can improve students' mathematical semiotic representations. These findings indicate that mathematical semiotic representation is an essential ability that deserves further investigation, particularly when viewed in relation to students' affective characteristics. This finding is consistent with Atikasuri & Al-Kusaeri (2024), who also reported that students' mathematical representation abilities can be observed through the way they construct mathematical representations when solving contextual problems. Addition, Savidamol & Sethu (2025) highlighted that students' fluency in constructing and transforming semiotic representations plays an important role in developing mathematical understanding. Therefore, analyzing students' mathematical semiotic representations provides deeper insights into their mathematical thinking processes. Nevertheless, the use of semiotic representations in

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mathematics learning is not only influenced by cognitive aspects but also by affective factors. One important affective factor is self-confidence. Self-confidence refers to an individual's belief in their ability to face situations and complete tasks Valerina & Abadi, (2022). Students with high self-confidence tend to be more active, confident in expressing their ideas, and willing to try different problem-solving strategies. In contrast, students with low self-confidence tend to be hesitant, less confident, and passive during the learning process (Ismiasih & Mustika, 2024). Similarly, Destiani (2025) reported that students with higher self-confidence were more willing to communicate mathematical ideas, participate actively during learning, and demonstrate greater persistence when solving mathematical problems. Likewise, Safitri et al., (2025) reported that differences in students' self-confidence are reflected in differences in their mathematical reasoning during problem solving.

Several previous studies have examined students' mathematical representation abilities, mathematical semiotic representation, and the role of self-confidence in mathematics learning. Ahmad et al., (2023) reported that self-confidence contributes to students' mathematical representation abilities, while (Yulinawati & Nuraeni, 2021) found that students with higher self-confidence generally demonstrate better representation abilities. Other studies have also discussed mathematical semiotic representation from the perspective of semiotic theory. However, studies that specifically examine students' mathematical semiotic representation abilities based on Peirce's indicators (iconic, symbolic, and indexical) in relation to different levels of self-confidence remain limited, particularly at the junior high school level. Therefore, this study aims to provide a qualitative description of students' mathematical semiotic representation abilities across different levels of self-confidence.

In addition, studies that integrate mathematical semiotic representation ability with students' self-confidence are still limited, particularly at the junior high school level. In fact, the integration of cognitive and affective aspects is essential in mathematics learning to achieve a more comprehensive understanding. Therefore, further research is needed to specifically analyze students' mathematical semiotic representation abilities across different levels of self-confidence. Based on the aforementioned discussion, this study provides a qualitative description of students' mathematical semiotic representation abilities on the iconic, symbolic, and indexical indicators across different levels of self-confidence. Rather than making broad generalizations, this study seeks to provide an in-depth understanding of how students with different levels of self-confidence construct mathematical semiotic representations when solving Pythagorean theorem problems. The findings are expected to contribute to the literature on the integration of cognitive and affective aspects in mathematics learning.

Mathematical Semiotic Representation ability is defined as the ability to express and interpret mathematical ideas through various semiotic signs including diagrams, mathematical symbols, verbal language, graphs, and other representations that convey mathematical meaning (Choiriyaza, 2017). Since mathematical objects are inherently abstract, they can only be accessed through semiotic representation systems (Duval, 2006). Consequently, understanding mathematics requires students not only to produce representations but also to interpret and coordinate different forms of representation to construct meaning (Presmeg et al., 2016). Based on Peirce's semiotic theory, mathematical semiotic representation can be examined through three interconnected indicators: iconic, symbolic, and indexical representations (Choiriyaza, 2017). These indicators provide the analytical framework for describing students' mathematical semiotic representation abilities across different levels of self-confidence in this study.

Method

Type of Research

This study employed a qualitative approach with a descriptive design. The qualitative approach was chosen because it aims to obtain an in-depth understanding of students' mathematical semiotic representation abilities in terms of their levels of self-confidence. Qualitative research is conducted through a systematic process of collecting, analyzing, and interpreting data to gain a comprehensive understanding of a phenomenon (Anto et al., 2024). Furthermore, descriptive research is intended to describe phenomena systematically and factually without manipulating the variables under investigation. Therefore, this study focuses on analyzing both the process and the results of students' mathematical semiotic representations in solving mathematical problems.

Subjects

This study was conducted with eighth-grade students of Class VIII-E at SMP Negeri 19 Tasikmalaya who had learned the Pythagorean theorem. The initial participants consisted of 26 students. The participants were selected using purposive sampling, which is a sampling technique that selects participants based on specific considerations relevant to the research objectives (Sugiyono, 2023). First, all participants completed a self-confidence questionnaire and were classified into high, medium, and low self-confidence categories based on predetermined score ranges. Subsequently, all participants completed a mathematical semiotic representation ability test. From the initial participants, three students were purposively selected as the research subjects, with one student representing each level of self-confidence (high, medium, and low). The selection was based on three criteria: (1) the results of the self-confidence questionnaire, (2) the mathematical semiotic representation ability test, and (3) the students' ability to provide clear and comprehensive information during the semi-structured interviews. These criteria were applied to obtain an in-depth understanding of students' mathematical semiotic representation abilities across different levels of self-confidence.

Instrument

The research instruments consisted of the researcher as the primary instrument and two supporting instruments: a self-confidence questionnaire and a mathematical semiotic representation ability test. In qualitative research, the researcher serves as the primary instrument, while supporting instruments are used to strengthen and cross-check the data obtained during the research process (Sugiyono, 2023). Students' self-confidence was measured using a self-confidence questionnaire modified from Sukmawati (2020), which was developed based on Lauster's self-confidence indicators: self-confidence in one's own abilities, independence in decision making, positive self-concept, and courage to express opinions. The questionnaire consisted of 16 statements, comprising 8 positive and 8 negative statements. It employed a four-point Likert scale with four response options: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). Positive statements were scored from 4 to 1, whereas negative statements were scored reversely from 1 to 4 (Sugiyono, 2023). The total questionnaire scores were then used to classify students into high, medium, and low self-confidence categories based on the score intervals presented in

Table 1. Categories of students' self-confidence questionnaire.

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Table 1. Categories of students' self-confidence questionnaire

No.	Categories	Interpretation
1	$X \geq M_i + Sb_i$	High
2	$M_i - Sb_i \leq X < M_i + Sb_i$	Medium
3	$X < M_i - Sb_i$	Low

X: Student score

M_i: Ideal mean = $\frac{1}{2}$ (highest score + lowest score)

Sb_i: Ideal standard deviation = $\frac{1}{6}$ (highest score – lowest score)

The distribution of self-confidence items presented in Table 2.

Table 2. Distribution of Self-Confidence Items

No.	Indicator	Questionnaire Statement	Type
1.	Belief in one's own ability	I am confident that I can speak in front of the class when explaining the lesson.	Positive
2.		I feel haunted by the fear of failure.	Negative
3.		I feel that other people are more capable than I am.	Negative
4.	Independence in desion-making	I try to act maturely when solving a problem.	Positive
5.		I complete assignments without assistance from others.	Positive
6.		I hesitate to complete difficult assignments without help from others.	Negative
7.		I feel dependent on others	Negative
8.	Positive self-concept	I can reflect on the failures I have experienced previously.	Positive
9.		I am optimistic that what I am working on will go well.	Positive
10.		I understand that failure can always happen.	Negative
11.		I feel less confident when I am among my friends	Negative
12.	Courage to express opinions	When there is a lesson I do not understand, I try to gather the courage to ask questions.	Positive
13.		I dare to express my opinions during discussions	Positive
14.		I dare to ask questions when something does not match what I know.	Positive
15.		I feel afraid when I am asked to express my opinion	Negative
16.		I feel embarrassed when speaking or presenting alone	Negative

Prior to data collection, the self-confidence questionnaire underwent expert validation by a lecturer in Guidance and Counseling and a professional counselor. The questionnaire was revised based on the validators' suggestions to improve the clarity, appropriateness, and relevance of the questionnaire items before being administered to the participants.

Students' mathematical semiotic representation ability was assessed using a written test consisting of one contextual problem related to the Pythagorean theorem. The test instrument was developed based on Peirce's semiotic indicators, namely iconic, symbolic, and indexical representations. The problem was designed to explore students' abilities to construct visual representations, apply appropriate mathematical symbols and formulas, and explain the relationship between the solution process, the obtained results, and the problem context. The distribution of the test indicators is presented in

Table 3.

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Table 3. Distribution of the test indicators

Learning Outcomes	Learning Objectives	Indicators of Mathematical Semiotic Representation Ability	Question Number
Students are able to demonstrate the validity of the pythagorean theorem and apply it in solving problems (including determining the distance between two points on the Cartesian coordinate plane)	1. Explain the validity of the pythagorean theorem 2. Solve daily -life problems related to the pythagorean theorem 3. Apply the pythagorean theorem	1. Iconic - Present data or information in the form of visual representations or diagrams. 2. Symbolic - Express problems using mathematical symbols. - Use mathematical symbols to solve problems. 3. Indexical - Explain cause-and-effect	1

An example of the mathematical semiotic representation ability test item is presented below.

> Rafi is a courier delivering a package from Tasikmalaya to Pangandaran by motorcycle. However, he must first scan the package barcode at the Ciamis branch office. Ciamis is located east of Tasikmalaya, while Pangandaran is located south of Ciamis. The road from Tasikmalaya to Ciamis is relatively congested, so Rafi travels at an average speed of 36 km/h and takes 30 minutes. The road from Ciamis to Pangandaran is less congested, allowing him to travel at an average speed of 48 km/h for 1 hour and 40 minutes. If Rafi did not need to stop in Ciamis, he could travel directly from Tasikmalaya to Pangandaran using a shorter route, reducing the travel distance by 16 km compared with the route through Ciamis.
>
> a. Draw the route taken by Rafi.
> b. Calculate and compare the distance traveled from Tasikmalaya to Ciamis and then to Pangandaran with the direct distance from Tasikmalaya to Pangandaran. State your conclusion.
> c. Explain the relationship between the travel route and the calculated distances. Why do the two routes result in different travel distances?

Before being used for data collection, the mathematical semiotic representation ability test instrument underwent expert validation by two mathematics education lecturers. The validation process aimed to evaluate the alignment between the test items and Peirce's semiotic indicators, the relevance of the problem to the Pythagorean theorem material, the clarity of the problem context, and the appropriateness of the language used. The instrument was revised based on the validators' suggestions and feedback to ensure that it was suitable for use in the study. The validated instrument was then used to collect data on students' mathematical semiotic representation abilities. The obtained data were analyzed qualitatively by referring to the iconic, symbolic, and indexical indicators to describe how students constructed mathematical semiotic representations when solving the Pythagorean theorem problem.

Data Collection

As illustrated in Figure 1, the study began with the administration of a self-confidence questionnaire to 26 Grade VIII-E students. The questionnaire results were used to classify students into high, medium, and low self-confidence categories. Subsequently, all students completed a mathematical semiotic representation ability test based on Peirce's semiotic indicators, namely iconic, symbolic, and indexical representations. Based on the questionnaire results, students' responses to the mathematical semiotic representation ability test, and interview findings, three research subjects representing high, medium, and low self-confidence levels were selected purposively for in-depth analysis. The data collected in this study consisted of self-confidence questionnaire results, mathematical semiotic representation ability test results, interview data, and documentation. To ensure the trustworthiness of the findings, source triangulation and technique triangulation were employed by comparing the data obtained from the questionnaires, written tests, and interviews.

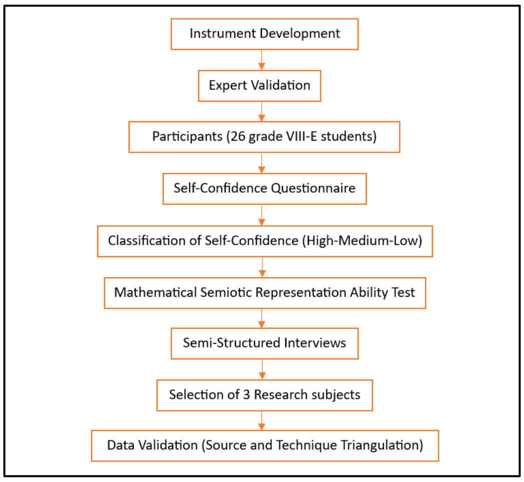

Figure 1. Research Procedure and Data Collection Process

Data Analysis

Data analysis in this study was conducted qualitatively on data obtained from various sources, namely the self-confidence questionnaire, mathematical semiotic representation ability test, and semi-structured interviews. The collected data were analyzed interactively and continuously through data triangulation to obtain an in-depth understanding of students' mathematical semiotic representation abilities across different levels of self-confidence. This is in accordance with Miles and Huberman's data analysis model in Sugiyono (2013), which states that qualitative data analysis is carried out interactively and continuously until the data become saturated. Therefore, the data analysis process in this study followed three stages: data reduction, data display, and conclusion drawing. In the data reduction stage, the researcher selected, focused, simplified, and organized the relevant information obtained from the field. The self-confidence questionnaire data were analyzed to classify students into high, medium, and low self-confidence categories based on predetermined score intervals, which were then used as the basis for selecting research subjects. Furthermore, students' responses to the mathematical semiotic representation ability test were analyzed qualitatively based on Peirce's semiotic indicators, namely iconic, symbolic, and indexical representations. The analysis focused on identifying how students constructed visual representations, applied mathematical symbols and formulas, and explained the relationship between the solution process, the obtained results, and the problem context. The students' written responses were coded according to these indicators to describe the characteristics of their mathematical semiotic representations. Interview data were also reduced by transcribing students' responses, identifying relevant statements, and coding information related to the semiotic indicators and self-confidence aspects. The interview results were used to clarify students' thinking processes and confirm the interpretations obtained from the written test responses.

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In the data display stage, the reduced data were organized and presented in the form of descriptive narratives. The data presentation included the classification of students based on their self-confidence levels, the analysis of students' mathematical semiotic representation abilities based on iconic, symbolic, and indexical indicators, and the results of interviews that supported the interpretation of students' written responses. Through this stage, the researcher was able to identify patterns and characteristics of students' mathematical semiotic representations across different levels of self-confidence. In the conclusion drawing stage, conclusions were obtained by interpreting the relationships among the data from the self-confidence questionnaire, mathematical semiotic representation ability test, and interviews. The findings from these three sources were integrated through triangulation to ensure the consistency of the interpretations. This process was used to provide a comprehensive qualitative description of students' mathematical semiotic representation abilities based on their levels of self-confidence when solving Pythagorean theorem problems.

Research Findings and Discussion

Based on the results of the self-confidence questionnaire, students were categorized into three levels of self-confidence, namely high, medium, and low. Following this classification, selected students from each category were given a mathematical semiotic representation ability test on the Pythagorean theorem material to explore their abilities in fulfilling the indicators of iconic, symbolic, and indexical representations. Furthermore, semi-structured interviews were conducted to obtain deeper information regarding students' thinking processes in solving mathematical problems based on their levels of self-confidence in Table 4.

Table 4. Research Subject

No.	Subject	Self-confidence	Indicators of Mathematical Representation Ability
1	S-6	High	Iconic, Symbolic, Indexical
2	S-9	Medium	Iconic, Symbolic, Indexical
3	S-7	Low	Iconic, Symbolic

Description of Students' Mathematical Semiotic Representation Ability Reviewed from High Self-Confidence

The findings from the mathematical semiotic representation ability test indicate that students with high self-confidence generally demonstrated iconic, symbolic, and indexical representations. Students demonstrated the ability to represent mathematical ideas through visual representations, mathematical symbols, and logical explanations. In addition, students were able to identify important information in the problem and explain the solution process systematically. These findings suggest that students with high self-confidence in this study showed a more organized approach in expressing mathematical ideas during the problem-solving process. This finding is consistent with Purwasih et al., (2023), who reported that students with a good understanding of mathematical concepts were able to produce complete iconic, symbolic, and indexical representations when solving geometry problems based on Peirce's semiotic perspective.

Iconic

Based on S-6's response to the mathematical semiotic representation ability test (Figure 2), the student was able to present the information provided in the problem in the form of a visual representation. This indicates that S-6 was able to illustrate the cardinal directions and position Tasikmalaya, Ciamis, and Pangandaran according to the information given in the problem, as well as construct a right triangle model to represent the travel route. To obtain deeper information regarding S-6's work on the first indicator, the researcher conducted an interview as follows.

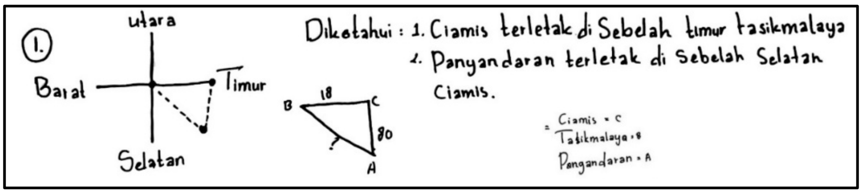

Figure 2. High Ability Answer (S-6)

P : "How did you represent the information given in the problem?"
S-6 : "I first identified the positions of Tasikmalaya, Ciamis, and Pangandaran based on the directions provided in the problem. Then, I drew a right triangle to illustrate the travel route."
P : "Why did you draw a right triangle?"
S-6 : "Because the route formed a right triangle, and the drawing helped me understand the relationship between the distances given in the problem."

The interview excerpt indicates that S-6 was able to interpret the information provided in the problem and transform it into an appropriate visual representation. The subject explained the meaning of each element in the drawing and related it to the context of the problem. The consistency between the written response and the interview results indicates that S-6 demonstrated the iconic representation indicator. This finding is consistent with Peirce's semiotic theory, which states that an icon represents an object or situation through a visual form that resembles the object being represented. The visual representation constructed by S-6 helped the subject illustrate the problem situation and identify the mathematical concepts involved. Furthermore, S-6 also demonstrated characteristics of self-confidence, including a positive self-concept and independence in making decisions. This finding is supported by Dewi and Hakim (2023), who reported that visual representations assist students in understanding, communicating, and relating mathematical concepts more effectively during the problem-solving process.

Symbolic

Based on S-6's response to the mathematical semiotic representation ability test, the student was able to represent the problem using mathematical symbols and apply mathematical operations during the solution process (Figure 3). This was demonstrated through determining the distance using the speed–time formula and applying the Pythagorean theorem to calculate the direct distance from Tasikmalaya to Pangandaran. In addition, S-6 was able to interpret the obtained calculation results in relation to the context of the problem. To obtain deeper information regarding S-6's work on the second indicator, the researcher conducted an interview as follows.

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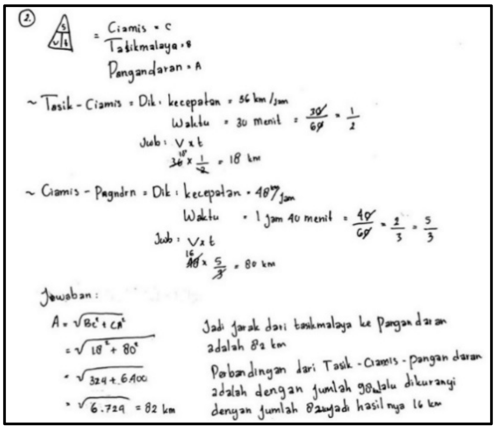


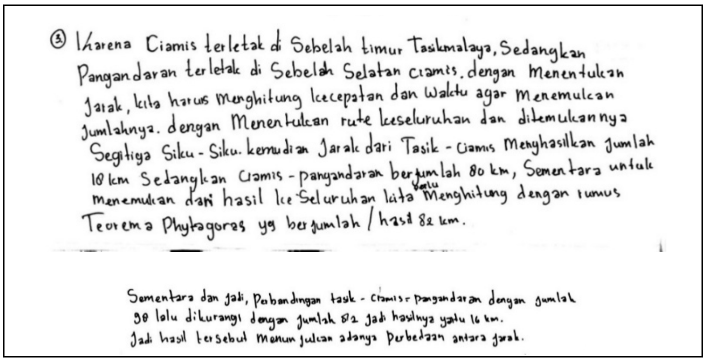
Figure 3. High Ability Answer (S-6)

P : "How did you determine the distance between the cities?"
S-6 : "First, I calculated the distance traveled by multiplying the speed and time. After obtaining the lengths of the two routes, I used the Pythagorean theorem to find the direct distance."
P : "Why did you use the Pythagorean theorem?"
S-6 : "Because the route formed a right triangle, so the direct distance could be determined using the Pythagorean theorem."

The interview excerpt indicates that S-6 understood the meaning of the mathematical symbols and formulas used in the solution process. The subject was able to represent the problem using mathematical symbols, apply mathematical symbols and formulas to solve the problem, and interpret the symbols in relation to the problem context. This finding is consistent with Peirce's semiotic theory, which explains that symbolic representation involves the use of signs, symbols, or mathematical notations whose meanings are understood through conventions or agreed rules. The consistency between the written response and the interview results suggests that S-6 was able to construct symbolic representations by applying and interpreting mathematical symbols appropriately during the problem-solving process. Furthermore, S-6 demonstrated a characteristic of self-confidence, namely confidence in their own abilities. This finding is in line with by Yulinawati & Nuraeni (2021), who reported that students with higher self-confidence tend to demonstrate better mathematical representation abilities in expressing mathematical ideas.

Indexical

Based on S-6's response to the mathematical semiotic representation ability test, the student demonstrated the indexical representation indicator by explaining the cause-and-effect relationship within the given problem and relating the calculation results to the context of the problem (Figure 4). This was indicated by S-6's ability to explain that the direct distance was shorter than the route through Ciamis because the route represented the hypotenuse of a right triangle. In addition, S-6 was able to draw an appropriate conclusion based on the obtained calculation results. To obtain deeper information regarding S-6's work on the third indicator, the researcher conducted an interview as follows.


③ Karena Ciamis terletak di Sebelah timur Tasikmalaya, Sedangkan Pangandaran terletak di Sebelah Selatan ciamis. dengan Menentukan Jarak, kita harus Menghitung kecepatan dan Waktu agar Menemukan Jumlahnya. dengan Menentukan rute keseluruhan dan ditemukannya Segitiga Siku-Siku. kemudian Jarak dari Tasik - Ciamis Menghasilkan Jumlah 18 km Sedangkan Ciamis - pangandaran berjumlah 80 km, Sementara untuk menemukan dari hasil keSeluruhan kita yaitu Menghitung dengan rumus Teorema Phytagoras yg berjumlah / hasil 82 km.

Sementara dan jadi, Perbandingan tasik - ciamis = pangandaran dengan jumlah 98 lalu dikurangi dengan jumlah 82 jadi hasilnya yaitu 16 km.
Jadi hasil tersebut menunjukkan adanya perbedaan antara jarak.

Figure 4. High Ability Answer (S-6)

P : "How did you know that your solution was correct?"
S-6 : "Because the result was correct. The direct distance from Tasikmalaya to Pangandaran is shorter than traveling through Ciamis first."
P : "What conclusion did you obtain from the calculation?"
S-6 : "The direct distance is shorter than the route through Ciamis, with a difference of 16 km."
P : "Why do you think the direct distance is shorter?"
S-6 : "Because the direct distance from Tasikmalaya to Pangandaran is the hypotenuse, while the route through Ciamis consists of two sides of a right triangle, so it is longer."

The interview excerpt indicates that S-6 was able to explain the relationship between the obtained results and the mathematical concepts used in the solution process. The subject not only performed the calculations correctly but also provided logical reasoning regarding why the direct distance was shorter than the route through Ciamis. The consistency between the written response and the interview results indicates that S-6 demonstrated the indexical representation indicator. This finding is consistent with Peirce's semiotic theory, which explains that an indexical represents an object through a factual relationship or a cause-and-effect connection. In this study, S-6 was able to establish a meaningful relationship between the visual representation, the calculation results, and the conclusion drawn from the problem situation. Furthermore, S-6 demonstrated a characteristic of self-confidence, namely the willingness to express opinions during the interview process. This finding is supported by Sabrina & Effendi (2022), who stated that students who are able to relate mathematical concepts to the information presented in a problem tend to construct more meaningful representations and provide logical explanations for their solutions.

Description of Students' Mathematical Semiotic Representation Ability Reviewed from Medium Self-Confidence

The findings from the mathematical semiotic representation ability test indicate that students with moderate self-confidence generally demonstrated the characteristics of mathematical semiotic representation indicators. Students were able to demonstrate iconic, symbolic, and indexical representations through visual representations, mathematical symbols, and logical explanations, although some inaccuracies and hesitation were still observed during the solution process. These findings suggest that students with moderate self-confidence in this study were able to understand the problem and construct mathematical representations, but they still showed uncertainty when explaining and interpreting the obtained results. This finding is consistent with Andayani & Amir (2019), who stated that students with moderate self-confidence generally have sufficient confidence in learning mathematics, although they may still experience hesitation when expressing their mathematical ideas.

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Iconic

Based on the Figure 5, S-9 was able to transform the information given in the problem into a visual representation appropriately. The subject identified the known and asked information and illustrated the situation related to the Pythagorean theorem. However, the representation made by the subject was still less detailed compared to students with high self-confidence. This indicates that the student understood the context of the problem, although the explanation provided was not entirely complete. The interview results further supported this finding, as shown in the following excerpt.

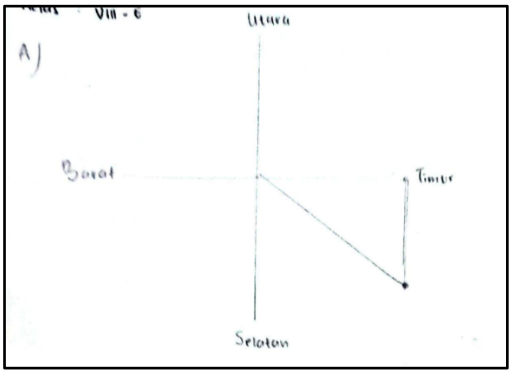

Figure 5. Medium Ability Answer (S-9)

P : "Can you explain how you understood the given problem?"
S-9 : "I read the problem first, then looked at the directions mentioned in the problem, so I tried to draw it to make it easier to understand."
P : "The problem states that Ciamis is located east of Tasikmalaya and Pangandaran is south of Ciamis. How did you represent this information?"
S-9 : "I first drew the cardinal directions, then placed Ciamis to the east and Pangandaran below it, and connected them with lines."
P : "Why did you make a drawing first?"
S-9 : "To make it easier to see the positions of the cities."
P : "Did the drawing help
S-9 : "Yes, it helped, but I was still a little unsure when I first drew it."

The interview excerpt indicates that S-9 was able to transform the information provided in the problem into a visual representation. The subject identified the positions of the cities based on the given directions and represented them through a drawing and a right triangle model. Although the visual representation created by S-9 was relatively simple and did not include complete labels for the cities, the subject was still able to explain the meaning of the drawing and relate it to the problem context. The consistency between the written response and the interview results indicates that S-9 demonstrated the iconic representation indicator. This finding is consistent with Peirce's semiotic theory, which states that an icon represents an object or situation through a visual form that resembles the object being represented. In this study, the visual representation constructed by S-9 functioned as an iconic representation that helped the subject understand the spatial relationships among the cities described in the problem. Furthermore, S-9 demonstrated a characteristic of self-confidence, namely confidence in their own abilities, although some hesitation remained when confirming the correctness of the answer. This finding is supported by Sabrina & Effendi (2022), who stated that visual representations can assist students in understanding mathematical situations and organizing information more effectively during problem solving.

Symbolic

Based on the Figure 6, S-9 demonstrated the symbolic representation indicator by using mathematical symbols and formulas related to the Pythagorean theorem. The subject applied mathematical operations and performed calculations during the solution process, although some inaccuracies were still observed in writing the solving steps. S-9 was able to relate the mathematical symbols and formulas used to the concepts involved in solving the problem. The interview results further supported this finding, as shown in the following excerpt.

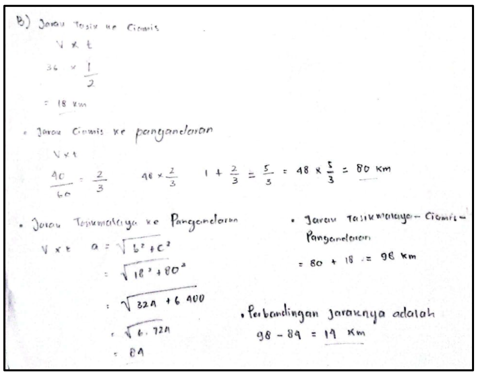

Figure 6. Medium Ability Answer (S-9)

P : "After making the drawing, how did you determine the distance between the cities?"
S-9 : "I used the formula distance equals speed multiplied by time because that is what I remembered and had learned before."
P : "Can you explain how you calculated it?"
S-9 : "I multiplied the speed by the time, but honestly, I was unsure when determining the time, so I recalculated it several times."
P : "After that, how did you find the direct distance?"
S-9 : "I used the Pythagorean theorem because the drawing looked like a right triangle."
P : "Why did you choose that method?"
S-9 : "Because, as far as I remember, right triangles are usually solved using that formula."
P : "Were you confident with your calculation results?"
S-9 : "Yes, although I was unsure at first."
P : "What does the result mean?"
S-9 : "I think it means that the final result shows different distances."

The interview excerpt indicates that S-9 was able to explain the use of mathematical formulas and symbols during the problem-solving process. The subject was able to represent the problem using mathematical symbols and apply mathematical operations in solving the problem. S-9 used the distance formula and the Pythagorean theorem based on the information provided in the problem, although some errors were still found in the calculation process. The consistency between the written response and the interview results indicates that S-9 demonstrated the symbolic representation indicator. This finding is consistent with Peirce's semiotic theory, which states that symbolic representation involves the use of signs, symbols, or mathematical notations whose meanings are understood through conventions or agreed rules. In this study, S-9 was able to apply mathematical symbols and formulas and relate them to the mathematical concepts used in solving the problem, although some uncertainty was still observed during the process. Furthermore, S-9 demonstrated a characteristic of self-confidence, namely confidence in their own abilities, although hesitation was still observed at the beginning of the solution process. This finding is supported by (Putra et al., 2025), who reported that students with adequate mathematical representation abilities are generally able to use

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mathematical symbols and notations appropriately in problem-solving activities, although they may still experience uncertainty during the solution process.

Indexical

Based on S-9's response to the mathematical semiotic representation ability test, the student demonstrated the indexical representation indicator by showing the relationship between the calculation results and the problem context, as well as drawing a conclusion (Figure 7). This was indicated by S-9's explanation regarding the difference between the direct distance and the route through Ciamis. However, an error occurred in calculating the direct distance, resulting in an inaccurate final answer. This indicates that S-9 had an understanding of the general situation of the problem but had not yet applied the calculation process accurately. To obtain deeper information regarding S-9's work on the third indicator, the researcher conducted an interview as follows.

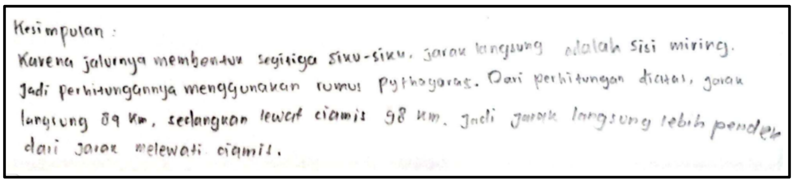
Kesimpulan :
Karena jalurnya membentuk segitiga siku-siku. Jarak langsung adalah sisi miring. Jadi perhitungannya menggunakan rumus Pythagoras. Dari perhitungan diatas, jarak langsung 89 Km, sedangkan lewat ciamis 98 km. Jadi jarak langsung lebih pendek dari jarak melewati ciamis.

Figure 7. Medium Ability Answer (S-9)

P : "After obtaining the answer, what do you think the result means?"
S-9 : "It means that the distances are different. One route is shorter than the route that goes through Ciamis."
P : "Why do you think the distances are different?"
S-9 : "Because the routes are different. One route goes directly to the destination, while the other goes through Ciamis first, so it is longer."
P : "Is there any relationship between the result and the drawing or formula you used?"
S-9 : "Yes, because the drawing formed a right triangle, so I used the Pythagorean theorem, although I was still a little confused at first."
P : "So, what conclusion can you draw from this problem?"
S-9 : "In my opinion, the conclusion is that the direct distance is shorter."
P : "Are you confident with your answer?"
S-9 : "Actually, I am not completely sure because I am afraid of making a mistake."

The interview excerpt indicates that S-9 was able to relate the calculation results to the context of the problem and explain the relationship between the mathematical procedures and the conclusion obtained. The subject explained the difference between the direct distance and the route through Ciamis and related the explanation to the right-triangle representation used in the solution process. However, the explanation provided was not yet fully accurate because an error occurred during the calculation process. The subject also expressed uncertainty when confirming the final answer. The consistency between the written response and the interview results indicates that S-9 demonstrated the indexical representation indicator, although the explanation was still relatively simple and delivered with some hesitation.

This finding is consistent with Peirce's semiotic theory, which explains that an indexical represents an object through a factual relationship or a causal connection. In this study, S-9 was able to establish a relationship between the mathematical procedures, calculation results, and the conclusion drawn from the problem situation. Furthermore, S-9 demonstrated a characteristic of self-confidence, namely the willingness to express opinions, although some hesitation remained when explaining and confirming the correctness of the answer. This finding is supported by Sabrina & Effendi (2022), who reported that students who are able to connect mathematical information, representations, and conclusions tend to demonstrate better understanding in problem-solving activities, although differences in confidence may influence how they communicate their reasoning.

Description of Students' Mathematical Semiotic Representation Ability Reviewed from Low Self-Confidence

The findings from the mathematical semiotic representation ability test indicate that students with low self-confidence showed several difficulties in demonstrating mathematical semiotic representation indicators. Students experienced difficulties in representing mathematical ideas through visual representations, mathematical symbols, and logical explanations. In addition, students showed hesitation when explaining the solution steps and interpreting the obtained results. These findings suggest that students with low self-confidence in this study tended to experience challenges in expressing mathematical ideas and explaining their reasoning during the problem-solving process. This finding is consistent with Hendriana (2014), who stated that students with low self-confidence may experience difficulties in expressing their ideas and engaging in mathematical problem-solving activities.

Iconic

Based on S-7's response to the mathematical semiotic representation ability test, the student demonstrated the iconic representation indicator by showing an attempt to represent the problem in the form of a visual representation (Figure 8). This was indicated by the cardinal direction illustration and the travel route sketch created by S-7. However, the representation was not yet fully accurate because there were errors in transforming the information from the problem into a visual form, and the drawing was not accompanied by sufficient labels, making the meaning of the representation difficult to interpret clearly. This indicates that S-7 was able to transform verbal information into a visual representation, but the representation was not yet accurate in describing the problem situation. To obtain deeper information regarding S-7's work on the first indicator, the researcher conducted an interview as follows.

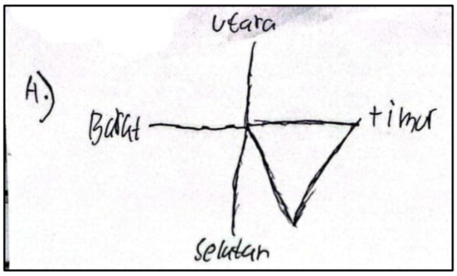

Figure 8. Low Ability Answer (S-7)

P : "In part A of your answer, you drew a picture. Can you explain the meaning of the drawing?"
S-7 : "I drew the cardinal directions, and it represents the route between the cities."
P : "Why did you make the drawing?"
S-7 : "To know the directions because the problem mentioned east and south."
P : "Do you think your drawing was correct?"
S-7 : "I think it was wrong because I was not sure."
P : "How did you determine the position of each city in the drawing?"
S-7 : "I do not know, I just estimated it."
P : "Did you try another method or did you only use this one?"
S-7 : "I only used this method."
P : "Did the drawing help you solve the problem?"

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S-7 : "It helped a little, but I was still confused when solving the next part."
P : "When you felt confused, what did you do?"
S-7 : "I just continued, but sometimes I was not sure whether it was correct or not."
P : "If you were asked to explain your answer, would you feel confident explaining it?"
S-7 : "Not really, because I am afraid of making mistakes."

The interview excerpt indicates that S-7 attempted to represent the information provided in the problem through a visual representation in the form of cardinal directions and a travel route sketch. The subject recognized the importance of directional information and attempted to illustrate the positions of the cities based on the information given in the problem. However, the representation was not yet based on adequate understanding, as S-7 was unable to provide sufficient explanations and supporting labels for the drawing. As a result, the visual representation created by S-7 was not fully accurate in describing the problem situation. The consistency between the written response and the interview results indicates that S-7 demonstrated an initial ability to construct an iconic representation, although the representation still required improvement in terms of accuracy and clarity.

This finding is consistent with Peirce's semiotic theory, which states that an icon represents an object or situation through a visual form that resembles the object being represented. In this study, S-7 attempted to construct an iconic representation by transforming verbal information from the problem into a visual form. However, the limitations in explaining the meaning of the representation and the lack of supporting information indicate that the iconic representation constructed by S-7 was not yet fully developed. Furthermore, this finding is in line with Yulinawati & Nuraeni, (2021), who reported that students with lower levels of self-confidence tend to experience hesitation when expressing mathematical ideas and may encounter difficulties in constructing mathematical representations during problem-solving activities.

Symbolic

Based on S-7's response to the mathematical semiotic representation ability test, the student demonstrated the symbolic representation indicator through the use of mathematical symbols and operations during the solution process (Figure 9). This was indicated by the use of speed, distance, and time formulas to calculate the travel distance for each route. In addition, S-7 was able to provide a simple explanation of the calculation steps performed. However, the use of mathematical symbols was not yet fully accurate and systematic. This indicates that S-7 was able to apply mathematical symbols in the problem-solving process, but the understanding and application of the mathematical concepts were not yet fully accurate and systematic. To obtain deeper information regarding S-7's work on the second indicator, the researcher conducted an interview as follows.

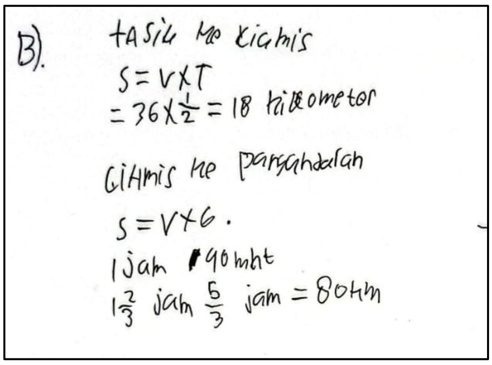

Figure 9. Low Ability Answer (S-7)

P : "In the calculation section, you used a formula. Can you explain which formula you used?"
S-7 : "I used the distance formula, which is distance equals speed multiplied by time."
P : "Why did you use that formula?"
S-7 : "Because the speed and time were given, so the distance could be calculated."
P : "How did you determine the values to substitute into the formula?"
S-7 : "I took the speed and time values from the problem and substituted them into the formula."
P : "For the distance from Ciamis to Pangandaran, how did you obtain the result?"
S-7 : "I simply multiplied the speed by the time and got the result."
P : "Were you confident with your calculations?"
S-7 : "Not really, because I was afraid there might be mistakes."
P : "Did you write down the known and asked information first?"
S-7 : "No, I directly started the calculations."
P : "What does the result you obtained mean?"
S-7 : "It represents the distance traveled."

The interview excerpt indicates that S-7 demonstrated the symbolic representation indicator through the use of mathematical symbols and operations during the solution process. The subject was able to transform the information provided in the problem into mathematical calculations and explain the results of the solution obtained. However, some inaccuracies were still found in the use of mathematical symbols, and the representation was not yet organized systematically. This indicates that S-7 was able to apply mathematical symbols in solving the problem, although the use and interpretation of mathematical symbols were not yet fully accurate. The consistency between the written response and the interview results indicates that S-7 demonstrated an initial ability to construct symbolic representation, although the representation still required improvement in terms of accuracy and systematic organization. In addition, S-7 demonstrated a characteristic of self-confidence, namely the willingness to express opinions, although the subject still experienced uncertainty regarding their ability and the correctness of the solution.

This finding is consistent with Peirce's semiotic theory, which states that symbolic representation involves the use of signs, symbols, or mathematical notations whose meanings are understood through conventions or agreed rules. In this study, S-7 was able to recognize and apply mathematical symbols and operations in the problem-solving process. However, the inaccuracies in using symbols and the lack of systematic organization indicate that the symbolic representation constructed by S-7 was not yet fully developed. Furthermore, this finding is consistent with Firnanda & Wahyuni (2024), who reported that students often experience difficulties in constructing complete symbolic representations because they are able to use mathematical symbols but have not fully understood their meanings and relationships within mathematical concepts. Similarly, Sutrisno et al., (2019) reported that students may experience difficulties in using mathematical representations systematically, particularly when translating information from problems into mathematical symbols and procedures.

Indexical

Based on S-7's response to the mathematical semiotic representation ability test, the student had not yet demonstrated the indexical representation indicator due to limitations in explaining the relationship between the calculation results and the problem context, as well as in drawing an appropriate conclusion (Figure 10). This was indicated by the absence of a clear explanation regarding the relationship between the obtained distance calculation results and the travel situation presented in the problem. In addition, S-7 had not yet been able to relate the solution steps taken to the mathematical concepts used appropriately. This indicates that S-7 still experienced difficulties in understanding cause-and-effect relationships and interpreting

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the obtained results. To obtain deeper information regarding S-7's work on the third indicator, the researcher conducted an interview as follows.

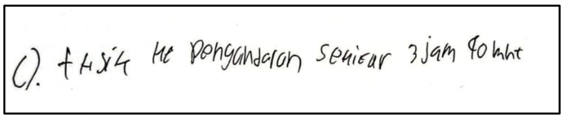

Figure 10. Low Ability Answer (S-7)

P : "After obtaining the calculation result, can you explain what the result in part C means?"
S-7 : "It is the distance traveled."
P : "What is the relationship between the result you obtained and the journey from Tasikmalaya to Pangandaran?"
S-7 : "It is the distance from Tasikmalaya to Pangandaran through Ciamis."
P : "Do you think the direct distance and the distance through Ciamis are the same or different?"
S-7 : "They are different, I think, but I do not really know why."
P : "Can you explain why they are different?"
S-7 : "I just added the results together, and that became the answer."
P : "Are you confident with the conclusion you made?"
S-7 : "Not really, because I am afraid of making mistakes."

The interview excerpt indicates that S-7 was able to identify the calculation results and mention the answer obtained from the problem. However, the subject was not yet able to explain the relationship between the calculation results and the problem context clearly. S-7's explanation mainly focused on the calculation procedures performed and did not yet demonstrate an understanding of the mathematical relationship between the direct distance and the route through Ciamis. In addition, S-7 was unable to relate the solution steps to the mathematical concepts used systematically and expressed uncertainty when explaining and confirming the obtained results. The consistency between the written response and the interview results indicates that S-7 had not yet demonstrated the indexical representation indicator optimally.

This finding is consistent with Peirce's semiotic theory, which explains that an indexical represents an object through a factual or causal relationship. In this study, S-7 was able to identify the result obtained from the calculation but experienced difficulty in establishing the relationship between the mathematical procedures, the representation used, and the meaning of the solution in the problem context. This difficulty indicates that the indexical representation constructed by S-7 was not yet fully developed. Furthermore, S-7 demonstrated characteristics of low self-confidence, namely hesitation in expressing opinions and uncertainty regarding the correctness of the solution. This condition may influence how students communicate and interpret their mathematical reasoning during problem solving. This finding is supported by Sutrisno et al., (2019), who reported that students may experience difficulties in connecting mathematical representations and interpreting the meaning of solutions conceptually, causing them to focus more on procedural calculations rather than the relationships among mathematical concepts.

The interview excerpt indicates that S-7 was able to identify the meaning of the calculation result at a basic level and relate it to the context of the journey described in the problem. However, the subject was unable to explain the mathematical relationship underlying the difference between the direct distance and the route through Ciamis. Instead, the explanation focused only on the calculation procedure performed. Furthermore, S-7 expressed uncertainty regarding the conclusion obtained. The consistency between the written response and the interview results suggests that the subject demonstrated limited indexical representation ability and had difficulty establishing meaningful relationships between the mathematical results and the concepts involved in the problem (Table 5).

Table 5. Qualitative Comparison of Students' Mathematical Semiotic Representation Abilities Based on Self-Confidence Levels

Indicators of Mathematical Semiotic Representation Ability	Subject		
	S-6 (High Self-Confidence)	S-9 (Medium Self-Confidence)	S-7 (Low Self-Confidence)
1	The subject was able to represent the given problem in the form of a visual representation by indicating the directions and the positions of the cities using the assumptions of a, b, and c, and modeling the situation as a right triangle.	The subject was able to represent the given problem in the form of a visual representation by illustrating the directions and positions of the cities. However, the subject did not provide labels for the cities at each point in the representation.	The subject was able to represent the given problem in the form of a visual representation by illustrating the directions and positions of the cities. However, there were inaccuracies in the constructed representation, and the subject did not provide labels for each city.
2	The subject was able to use mathematical symbols and operations accurately and systematically by transforming the problem into mathematical symbols and applying the Pythagorean theorem.	The subject was able to use mathematical symbols and operations accurately and systematically by transforming the problem into mathematical expressions and applying the Pythagorean theorem. However, an error occurred in the Pythagorean theorem calculation process.	The subject was able to use mathematical symbols and operations in solving the problem by transforming the given information into mathematical expressions. However, the use of mathematical symbols was not yet fully accurate and systematic.
3	The subject was able to explain the relationship between the obtained results and the problem context and draw logical conclusions.	The subject was able to explain the relationship between the obtained results and the problem context and draw logical conclusions. However, an error occurred in determining the final result	The subject was not yet able to explain the relationship between the obtained results and the problem context or draw logical conclusions.

The comparison presented in Table 5 shows qualitative differences in students' mathematical semiotic representation abilities across high, medium, and low self-confidence levels. Students with high self-confidence (S-6) demonstrated more complete mathematical semiotic representations because they were able to construct iconic, symbolic, and indexical representations systematically. The subject was able to visualize the problem situation, apply mathematical symbols and procedures appropriately, and establish meaningful relationships between mathematical results and the context of the problem. Students with medium self-confidence (S-9) were able to demonstrate all indicators of mathematical semiotic representation, although hesitation and calculation errors were still observed during the problem-solving process. Meanwhile, students with low self-confidence (S-7) showed limitations in mathematical semiotic representation, particularly in indexical representation, as the subject experienced difficulty in connecting mathematical procedures, obtained results, and contextual meanings. Overall, the differences in students' iconic, symbolic, and indexical representations indicate that mathematical meaning is constructed through a sequence of semiotic processes rather than through isolated representations. This finding is consistent with

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Fitriyah (2021), who emphasized that students' problem-solving processes can be interpreted through the development and coordination of semiotic representations.

From Peirce's semiotic perspective, these findings demonstrate that mathematical semiotic representation provides a framework for understanding how students construct meaning when solving mathematical problems. Iconic representation reflects students' ability to transform problem situations into visual forms, symbolic representation illustrates the use of mathematical signs, symbols, and procedures, while indexical representation reveals students' ability to establish relationships between mathematical representations and contextual meanings. Therefore, Peirce's semiotic theory contributes to interpreting students' mathematical responses by explaining not only the representations produced by students but also how meaning is constructed through those representations (Peirce,1960). This finding is in line with Presmeg et al., (2016), who emphasized that semiotic analysis enables researchers to understand how learners interpret mathematical ideas through multiple forms of representation. Furthermore, Billion (2023) argued that learners' mathematical understanding is reflected not only in the representations they produce but also in their actions of constructing, interpreting, and transforming those representatiosns during the learning process. This perspective reinforces the interpretation that students' mathematical representations in this study reflect their processes of mathematical meaning-making rather than merely the correctness of their final answers. This interpretation is also supported by Aziz et al., (2026), who argued that mathematical reasoning can be explained through Peirce's semiotic trichotomy, where the relationships among icons, symbols, and indexes reveal students' processes of constructing mathematical arguments. Accordingly, the students' mathematical representations identified in this study reflect not only procedural performance but also the development of mathematical reasoning. Similarly, Purwasih et al., (2025) emphasized that mathematical semiotics enables researchers and educators to understand students' mathematical thinking through semiotic representations. This perspective is further supported by Duval (2006), who argued that mathematical understanding develops through the coordination of different semiotic representation registers rather than relying on a single representation. Therefore, interpreting students' semiotic representations should focus not only on the final mathematical product but also on how students construct and communicate mathematical meaning throughout the problem-solving process.

Implication of research in learning

The findings of this study imply that mathematics teachers need to pay greater attention to students' mathematical semiotic representation abilities during the learning process. Assessment should focus not only on students' final answers but also on how they construct and communicate mathematical meaning through iconic, symbolic, and indexical representations. Providing opportunities for students to interpret diagrams, use mathematical symbols appropriately, and explain the relationships between mathematical procedures and problem contexts may help teachers identify students' conceptual understanding more comprehensively. Likewise, Purwasih et al., (2025) argued that mathematical semiotics enables educators to understand students' mathematical thinking through their semiotic representations.

The findings also suggest that self-confidence should be considered when designing mathematics learning activities. Although this study does not establish a causal relationship, students with higher self-confidence demonstrated more complete mathematical semiotic representations than those with lower self-confidence. Therefore, Teachers are encouraged to create a supportive classroom environment by providing opportunities for students to explain their reasoning, discuss multiple solution strategies, and reflect on their mathematical representations. Such learning experiences may strengthen students' confidence while improving their ability to communicate mathematical ideas. This implication is supported by Ahmad et al., (2023), who reported that self-confidence contributes to students' mathematical representation abilities. Similarly, Yulinawati & Nuraeni (2021) found that students with higher self-confidence generally demonstrate better mathematical representation abilities.

Furthermore, the findings of this study suggest that mathematics instruction should integrate both cognitive and affective aspects to support students' mathematical learning. Learning activities should encourage students to construct and communicate mathematical ideas through iconic, symbolic, and indexical representations while simultaneously fostering their self-confidence. Teachers may facilitate this process by providing contextual mathematical problems, encouraging collaborative discussions, and asking students to explain the reasoning behind their solutions. Such learning experiences may help students develop a deeper conceptual understanding of mathematics while improving their ability to communicate mathematical ideas confidently. This implication is consistent with Duval (2006), who emphasized that meaningful mathematical understanding develops through the coordination of multiple semiotic representations.

Conclusion

The findings of this study show qualitative differences in students' mathematical semiotic representation abilities across high, medium, and low levels of self-confidence. Students with high self-confidence (S-6) demonstrated complete mathematical semiotic representations by showing iconic, symbolic, and indexical representations. The subject was able to transform problem information into visual representations, apply mathematical symbols and procedures appropriately, and establish relationships between mathematical representations and the context of the problem. Students with medium self-confidence (S-9) were also able to demonstrate iconic, symbolic, and indexical representations. However, although the subject was able to construct appropriate representations and explain the solution process, some hesitation and calculation errors were still observed. Meanwhile, students with low self-confidence (S-7) demonstrated iconic and symbolic representations but experienced difficulty in indexical representation, particularly in explaining the relationship between mathematical procedures, obtained results, and the context of the problem. Overall, this study provides a qualitative description of how students with different levels of self-confidence construct mathematical semiotic representations when solving Pythagorean theorem problems. Peirce's semiotic framework helps interpret students' mathematical responses by describing how visual forms, mathematical symbols, and contextual meanings are constructed during the problem-solving process. Further studies may involve broader subjects and explore mathematical semiotic representation abilities in other mathematical topics or through different affective factors.

Conflict of Interest

The author declares no conflict of interest.

Auhor Contributions

B.P.A understood the research ideas presented and collected the data. Meanwhile, D.S and L.H contributed significantly to the development of the theoretical framework and methodology, as well as to data organization, analysis, discussion of findings, and final approval of the manuscript. All authors confirm that they have reviewed and agreed upon the final version of

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the paper. The distribution of contributions for the conceptualization, drafting, and revision of this study is as follows: B.P.A.: 40%, D.S.: 30%, and L.H.: 30%.

Data Availability Statement

The authors declare that data supporting the results of this study will be made available by the corresponding author, [D.S], upon reasonable request..

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