



Jurnal Pendidikan Matematika (Kudus)

P-ISSN 2615-3939 | E-ISSN 2723-1186

<https://journal.iainkudus.ac.id/index.php/jmtk>

DOI: <http://dx.doi.org/10.21043/jpmk.v9i1.34671>

Volume 9, Number 1, June 2026, pp. 141-160

Identifying Cognitive Conflict in Junior High School Students: An Exploratory Case Study on Pythagorean Theorem Problem Solving

Siti Tri Rahayu¹, Della Maulidiya^{1*}, Tria Utari¹, Ratnah Lestary¹

¹*Department of Mathematic Education, University of Bengkulu*

*Correspondence: della.maulidiya@unib.ac.id

Abstract

Learning difficulties experienced by students in geometry, particularly with the Pythagorean Theorem, often stem from deep-seated misconceptions and epistemological resistance to new information. Addressing students' misconceptions begins with a deep understanding of the cognitive conflicts they are experiencing. Identifying these conflict mechanisms is an initial diagnostic step for designing effective and sustainable learning strategies. This study aims to deeply describe how specific misconceptions in the Pythagorean Theorem trigger cognitive conflict types (Type I, Type II, and Type III) in students. The research used a descriptive qualitative approach with exploratory case study type. The research subjects were six students from 28 grade IX students at SMPN 11 Bengkulu City, who were then analysed through written tests, observation of physical symptoms (video recordings), and semi-structured interviews. The research findings identified that all types of cognitive conflict appeared in the subjects. Type I Conflict (Initial Concept vs. New Environment) is triggered by the inability to model the geometric decomposition problem and the misidentification of the hypotenuse, resulting in anomalous outcomes that challenge students' initial beliefs. Type II Conflict (New Concept vs Old Environment/Habits) arises when an incorrect procedural schema (R1) is maintained despite the student's potential to activate the correct concept (C2). Meanwhile, Type III Conflict (Initial Concept vs New Concept) is internal, dominant in problems involving special triangle ratios, and signifies a conflict between the dominant general Pythagorean schema and the specific ratio schema that has not yet been stably assimilated. This research underscores the importance of learning strategies in a planned manner that can eliminate the cognitive conflict through instructional design, followed by strong visual scaffolding, to facilitate stable conceptual accommodation.

Keywords: Case Study; Cognitive Conflict; Misconception; Problem Solving; Pythagorean Theorem

Abstrak

Hambatan belajar yang dialami siswa dalam geometri, khususnya Teorema Pythagoras, seringkali bersumber dari miskonsepsi yang mendalam dan resistensi epistemologi terhadap informasi baru. Penanganan miskonsepsi peserta didik diawali dengan pemahaman mendalam terhadap konflik kognitif yang mereka alami. Identifikasi mekanisme konflik tersebut merupakan tahap diagnostik awal untuk merancang strategi pembelajaran yang efektif dan berkelanjutan. Penelitian ini bertujuan untuk mendeskripsikan secara mendalam bagaimana miskonsepsi spesifik dalam Teorema Pythagoras memicu tipe-tipe konflik kognitif (Tipe I, Tipe II, dan Tipe III) pada siswa. Penelitian menggunakan pendekatan kualitatif deskriptif dengan jenis Studi Kasus Eksploratori. Subjek penelitian dipilih sebanyak enam siswa dari 28 peserta didik kelas IX di SMPN 11 Kota Bengkulu, yang kemudian dianalisis melalui tes tertulis, observasi gejala fisik (rekaman video), dan wawancara semi-terstruktur. Hasil penelitian mengidentifikasi bahwa semua tipe konflik kognitif muncul pada subjek. Konflik Tipe I (Konsep Awal vs Lingkungan Baru) dipicu oleh ketidakmampuan memodelkan masalah dekomposisi geometris dan misidentifikasi hipotenusa, menghasilkan hasil anomali yang menantang keyakinan awal siswa. Konflik Tipe II (Konsep Baru vs Lingkungan Lama/Kebiasaan) muncul ketika skema prosedural yang salah (R1) dipertahankan meskipun siswa memiliki potensi untuk mengaktifkan konsep yang benar (C2). Sementara itu, Konflik Tipe III (Konsep Awal vs Konsep Baru) bersifat internal, dominan pada masalah rasio segitiga istimewa, menandakan pertentangan antara skema umum Pythagoras yang dominan dengan skema rasio spesifik yang belum terasimilasi secara stabil. Penelitian ini menggarisbawahi pentingnya strategi pembelajaran secara terencana yang dapat menekan konflik kognitif melalui desain instruksional, diikuti dengan scaffolding visual yang kuat, untuk memfasilitasi akomodasi konseptual yang stabil.

Kata Kunci: Konflik Kognitif; Miskonsepsi; Pemecahan Masalah; Studi Kasus; Teorema Pythagoras

Introduction

Mathematics, as a fundamental foundation for science and technology, requires a strong conceptual understanding, especially in the branch of geometry (Novianda, 2022). Despite its importance, students' geometry skills at the secondary school level in Indonesia often fall below expected standards. Data from the 2022 Programme for International Student Assessment (PISA) shows that Indonesia's average mathematical literacy score is only 379, far below the average score of 427 for OECD countries. This figure places Indonesia in 68th place out of 81 participating countries, underscoring the urgency of improving student understanding, particularly in mathematical literacy (Kemendikbudristek, 2023). The Pythagorean Theorem is a geometry topic that has a moderate level of difficulty, but requires a very high level of conceptual understanding and accuracy for correct problem solving (N. Hidayah & Hasanudin, 2024). This indicates the need to improve students' understanding of mathematics, science, and reading literacy further.

Observations and interviews conducted at SMPN 11 Bengkulu City confirmed significant learning barriers in this topic. Students frequently misplaced formulas, confused the hypotenuse with the right angle, and struggled to use side ratios in special triangles. These difficulties were reinforced by previous research findings that identified student misconceptions including an inability to determine the required side, misunderstanding the converse of the Pythagorean theorem, and errors in modelling everyday mathematical problems (Sari, Herdita, P., Fuadiah, N. F., 2021). Further research detailed specific student errors, such as difficulty in decomposing complex shapes into right triangles, errors in arithmetic operations involving squares and square roots, and an inability to translate word problems into appropriate mathematical models (Maylinda et al., 2019; Faisal et al., 2023; Rian et al., 2024). These errors indicate that the challenges are not only procedural but also rooted in conceptual misunderstandings.

Learning difficulties are often not caused by intellectual disabilities, but rather because students are caught in a situation of uncertainty or hesitation (disequilibrium) when the solutions they have do not match the results they should get (Ifada & Ruli, 2024). Amalia and Unaenah (2018) states that learning difficulties are a situation where students are unable to learn well in an academic environment, making it difficult for them to learn as they should (Indrawati et al., 2024). Nurjannah (2019) states that learning difficulties experienced by students can cause obstacles in the learning process which results in less than optimal learning achievement (Indrawati et al., 2024). Students who experience learning disabilities will exhibit behaviour (physical symptoms) that indicate learning difficulties. Students will have difficulty improving their performance and absorbing new material because they have not fully understood the old material (A. Hidayah & Maemonah, 2022).

This condition is called cognitive conflict, defined as an imbalance between the organized knowledge structure in the brain (cognitive schema) and the environment or new information received (Gyounggho & Jaesool, 2001). Piaget's theory emphasizes that cognitive conflict is an essential trigger for the equilibration process, which involves assimilation (incorporating new information into old schemas) and accommodation (revising old schemas to accommodate new information). Therefore, cognitive conflict plays a crucial role in refreshing students' concepts and correcting misconceptions. According to Kwon's model, cognitive conflicts are categorized into three specific types based on the interaction between an individual's internal cognitive structure (Gyounggho & Jaesool, 2001). Type I conflict (C1 vs. R2) occurs when existing concepts clash with a new problem situation. Type II conflict (C2 vs. R1) arises when newly learned concepts cannot

replace old habitual ways of thinking. Type III conflict (C1 vs. C2) is a purely internal conflict between two competing concepts or schemas within an individual's mind. C1 represents a student's preconceptions or misconceptions. C2 represents a scientific concept to be learned. R1 represents the environment that can be well explained by C1. R2 represents the environment that can only be explained by C2. R1 and R2 do not represent a single external phenomenon. They represent the totality of observations and stimuli from one's environment.

Although many studies have classified the types of errors students make in the Pythagorean Theorem, the focus tends to be on the product of the error, rather than on the cognitive mechanisms underlying the resistance to conceptual change. For example, misconceptions are often classified as correlational (wrong units) or classificatory (wrong side length), but are rarely associated with internal conflict structures. This study aims to fill this gap by applying Kwon and Lee's cognitive conflict model, which classifies conflicts into three specific types (Type I: C1 vs R2, Type II: C2 vs R1, and Type III: C1 vs C2). The novelty of this study lies in its in-depth exploratory analysis of how specific misconceptions in the context of the Pythagorean Theorem (such as geometric decomposition problems and the use of special triangle ratios) manifest in Kwon's three types of conflict.

Addressing students' misconceptions begins with a thorough understanding of the cognitive conflicts they experience. Identifying the mechanisms of these conflicts is a crucial initial diagnostic step in designing effective and sustainable learning strategies. Without identifying the type of cognitive conflict experienced, learning interventions risk being generic and failing to address the specific cognitive barriers that hinder conceptual change. Therefore, the primary objective of this exploratory case study is to describe the types of cognitive conflicts (Types I, II, and III) that emerged during the Pythagorean Theorem problem-solving process at SMPN 11 Bengkulu City; what are the characteristics of Type I, II and III conflicts experienced by students and what is the mechanism of cognitive conflict in students when facing contradictions between their misconceptions and the formal concept of the Pythagorean Theorem? These findings are expected to provide a basic reference for developing more targeted and effective mathematics learning strategies, particularly in addressing persistent misconceptions in geometry.

Method

This research used a descriptive qualitative approach with an Exploratory Case Study type. This research specifically used a Multiple Case Study design because it involved in-depth analysis of more than one case subject, which aimed to gain a more comprehensive understanding of the diverse phenomena of cognitive

conflict. The research was conducted in class IXB SMPN 11 Bengkulu City in the odd semester of the 2025/2026 academic year. Class IX was chosen because at the time of the research, the Pythagorean Theorem had not yet been taught in class VIII, so the researcher could identify the initial schema (C1) that students had before formally receiving the new conceptual schema (C2) in the tested context. The total study population was 28 class IXB students. Subject selection was based on triangulation of written test results, observation of physical symptoms indicating disequilibrium (through video recordings), and interviews. From this population, six students were selected as the main subjects for the multiple case study. The selection of subjects who experience misconceptions and show symptoms of conflict was a deliberate strategy, because these students were in an active conceptual transition phase, which was most valuable for exploratory studies of cognitive conflict processes.

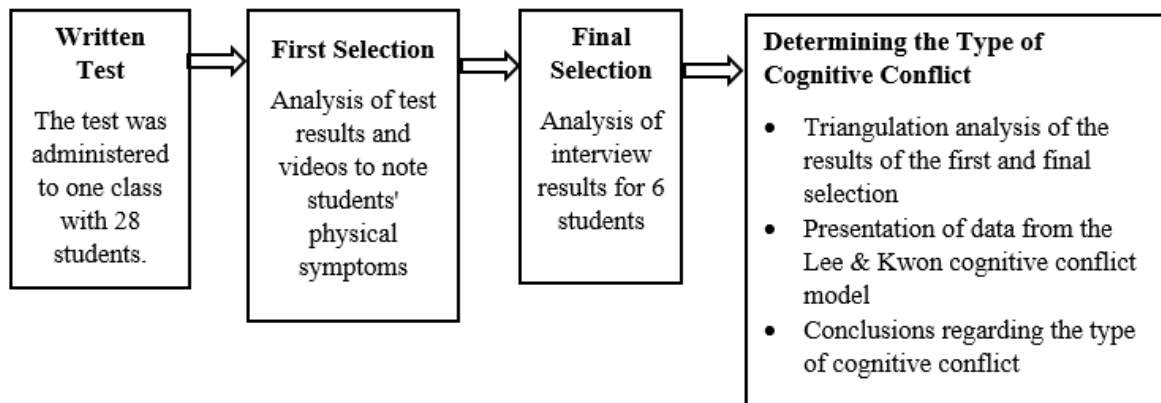


Figure 1. Selection of Research Subjects
Adapted from: (Lee & Kwon, 2002)

Data collection techniques were conducted through instrument triangulation, namely tests, semi-structured interviews, and documentation (video observation). Cognitive Conflict Test Instrument: Three descriptive questions were arranged based on a grid to test the ability of the Pythagorean Theorem material. The questions were designed to trigger specific types of cognitive conflict: Questions 1 and 2 were designed to test understanding of geometric concepts and decompositions, which often trigger Type I and II Conflicts, while Question 3 (special triangle ratios) was designed to trigger Type III Conflict. The validity of the instrument was logically tested by expert validators using the Aiken Index, and the results showed that the instrument was in the very valid category. Documentation Observation: The subjects' non-verbal physical symptoms were recorded during the test through real-time video recordings with two cameras. The observed symptoms (e.g., mumbling, flipping through paper, lowering the head, sighing) served as

objective indicators that the students were in a phase of disequilibrium or anomaly recognition. Semi-structured interviews were used to confirm and delve deeper into the subjects' thought processes. The interview guide focused on four indicators of cognitive conflict: recognition of anomalous situations, interest, anxiety/worry, and cognitive reappraisal processes.

Data analysis was conducted interactively and continuously using the Miles and Huberman model. The stages included: data reduction (summarizing raw data) from test results (identifying conceptual errors), interview transcripts (identifying verbal conflicts), and physical symptom observation notes. This reduction focused on six selected subjects based on indicators of cognitive conflict experienced, in the form of errors in solving the given problems, confusion during interviews, and the presence of physical symptoms recorded during the work process. Data presentation was presented in the form of descriptive narratives for each subject case, supported by a diagram of the Kwon and Lee conflict model, and a classification table of key findings. Conclusions were drawn through data triangulation (tests, observations, interviews) to definitively identify and group the types of cognitive conflicts that emerged, answering the research objectives comprehensively.

Results

This study identified six subjects experiencing significant cognitive conflict out of 28 students. Kayla, Ahmad, Roni, Anjas, Kenzi, and Nayla (pseudonyms) were the six students selected as research subjects. Based on the results of triangulation analysis, it was found that the cognitive conflicts that emerged were divided into the three types classified by Kwon and Lee. The most common types of conflict were Type I and Type III.

Table 1. Classification of Cognitive Conflict and Conceptual Barriers

Conflict Type	Subject	Problem Triggers	Conceptual Barriers
Type I (C1 vs R2)	Kayla, Ahmad, Nayla, Kenzi	Geometric decomposition problems (questions 1 and 2)	Inability to model non-routine problems; misconception of hypotenuse identification
Type II (C2 vs R1)	Anjas	Decomposition problem (question 2)	Faulty thinking habits (R1) are maintained; failure of conceptual restructuring
Type III (C1 vs C2)	Kayla, Roni, Kenzi, Nayla	Special Triangle Ratio (Question 3)	Specific schema (ratio) not assimilated; internal conflict (general vs specific schema)

Non-verbal observation through video recordings validated that the subjects experienced disequilibrium (imbalance) when facing with anomalous situations. Student Kayla, who experienced type I and III conflicts, showed physical symptoms of flipping the answer sheet. Student Ahmad, who experienced type I conflicts, showed physical symptoms of mumbling and lowering his head. Student Roni, who experienced type III conflicts, showed physical symptoms of shaking his pen and mumbling. Student Anjas, who experienced type II conflicts, showed physical symptoms of frowning and sighing. Student Kenzi, who experienced type I and III conflicts, showed physical symptoms of shaking his pen and lowering his head. Student Nayla, who experienced type I and III conflicts, showed physical symptoms of mumbling and flipping the answer sheet.

Recorded physical symptoms, such as mumbling, head lowering, sighing, and flipping through paper, serve as empirical evidence validating Piagetian disequilibrium theory. These movements directly indicate the anxiety and cognitive reappraisal phases experienced by students. For example, Anjas sighed while struggling with R1 and C2. Meanwhile, Ahmad lowered his head after realizing the anomalous results. These non-verbal observations confirm that cognitive conflict analysis requires an in-depth triangulation approach, not just relying on written answers.

The Emergence of Type I Cognitive Conflict (Initial Concept vs New Environment)

Type I cognitive conflict arises when students face geometric decomposition problems that require solving into two separate right triangles, as in Problems 1 and 2. These problems require higher mathematical modelling skills than the direct application of the Pythagorean theorem. The main obstacles identified are students' inability to model non-routine geometric problems and misidentification of the hypotenuse. Students try to apply the basic scheme of the Pythagorean theorem ($C1: c^2 = a^2 + b^2$) In complex situations (R2) that are not appropriate, resulting in incorrect solutions. Four subjects experienced this conflict significantly, namely Kayla, Ahmad, Nayla, and Kenzi. As a prime example, Kayla demonstrated clear conflict characteristics when solving Problem 2. She used the formula $BC^2 = AB^2 - AC^2$ which was not correct, then continued with the correct but inconsistent steps.

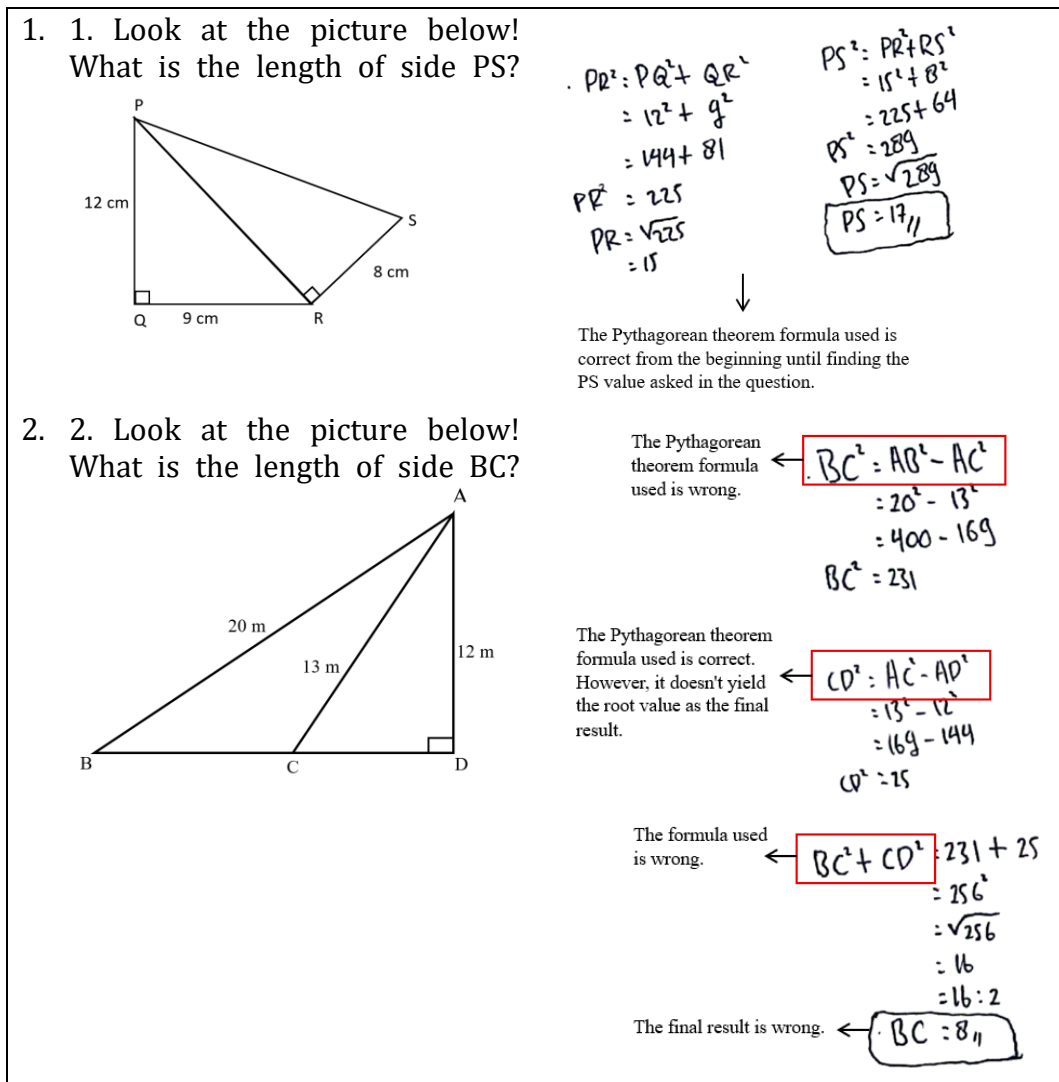


Figure 2. Kayla's Answers to Questions 1 and 2

In question number 2, Kayla used the wrong Pythagorean theorem formula in the first step, so the result she got was wrong. Then she continued the second step with the correct Pythagorean theorem formula, but did not get the final result because she did not take the root. The final step Kayla used to get the value of BC was also incorrect, so Kayla did not get the correct value of BC.

Based on the test results and observed characteristics, the researcher conducted an in-depth analysis of Kayla to find the cause of the conflict. The following is an excerpt from an interview with Kayla.

P : "I want to ask about question number 2, you use the formula $BC^2 = AB^2 - AC^2$, and also count $CD^2 = AC^2 - AD^2$. In your opinion, is the formula you are using correct or not?"

Kayla : "Not yet, ma'am."

- P : "But is the answer you gave correct or not?"
 Kayla : "Not yet, ma'am."
 P : "While you were working on this question, did you encounter any difficulties? What were the difficulties?"
 Kayla : "There is, ma'am, I'm confused about which formula to use, and I'm confused about which one to look for first, ma'am."
 P : "Do you feel worried when working on these questions?"
 Kayla : "There is, ma'am. I'm worried about the formula used and worried about doing it wrong, ma'am."
 P : "Is there any part of these questions that makes you stressed?"
 Kayla : "There is, ma'am. I'm stressed about number 2 because I'm confused about two triangles, and I'm confused about which one to look for first."

Student Kayla tried to calculate the length of side BC directly, which was impossible because BC was not a side of a single right triangle. She actually used the formula $BC^2 = AB^2 - AC^2$, which indicated an inability to identify the true structure of the problem. When interviewed, Kayla expressed her confusion: "I'm confused about which formula to use, and I'm confused about which one to look for first, ma'am."

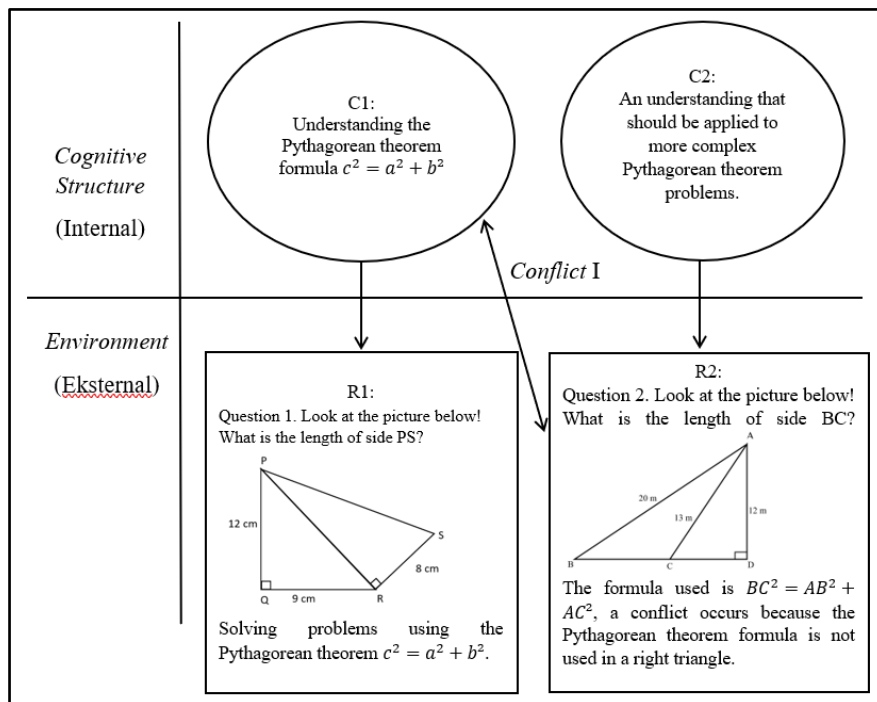


Figure 3. Type I Cognitive Conflict Diagram of Kayla

Student Kayla experienced Type I cognitive conflict when she interacted with a complex math problem (new environment/R2) that could not be solved only with her initial knowledge (C1) of the simple Pythagorean theorem. This was evident from the interview results. Kayla said, "I'm confused about which formula to use,

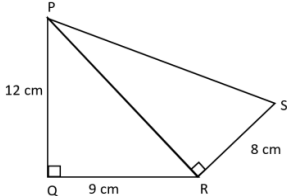
and I'm confused about which one to look for first, ma'am." This indicates that Kayla experienced Type I cognitive conflict where her initial knowledge (C1) did not match the problem structure (R2).

Accompanying physical symptoms included repeatedly flipping through answer sheets, indicating cognitive discomfort. Other subjects, such as Ahmad, experienced similar conflict, even producing negative squared values that he acknowledged were "strange" and "nonsensical," while Nayla admitted to using "random" formulas due to confusion. Ahmad's answer to Question 2, which yielded $BC^2 = -231$, is an example of an anomaly that challenges students' initial beliefs about the application of the Pythagorean theorem. This negative value contradicts the prior knowledge that the square of a side length must be positive, triggering the recognition of an anomalous situation.

The Emergence of Type II Cognitive Conflict (New Concept vs Old Environment)

Type II conflict is identified in the context of a geometric decomposition problem (Problem 2), where students have corrected conceptual understanding but maintain incorrect procedural habits. The core of this conflict lies in the dominance of the old environment (R1) in the form of incorrect procedural habits over the new concept (C2) that is actually understood. Students are able to produce the correct final answer through incorrect steps, demonstrating a fragile conceptual understanding.

1. 1. Look at the picture below! What is the length of side PS?



Dik: $PQ = 12 \text{ cm}$
 $QR = 9 \text{ cm}$
 $RS = 8 \text{ cm}$
 $PS = \dots ?$

$$PS^2 = PQ^2 + RS^2$$

$$= 12^2 + 8^2$$

$$= 144 + 64$$

$$= 208$$

$PS = \sqrt{208}$

The Pythagorean theorem formula used is wrong.

The final result is wrong.

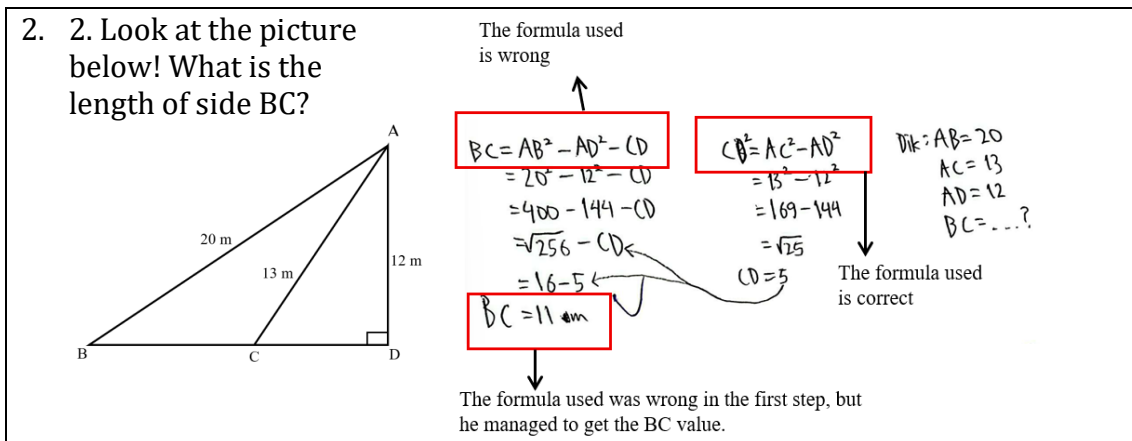


Figure 4. Anjas' Answers to Questions 1 and 2

In question number two, student Anjas used the wrong formula in the first step and the correct formula in the second step to find the length of side BC. The first step should have been to write the formula to find the length of side BD. Despite the error in the initial step, student Anjas managed to find the length of side BC correctly.

Based on the test results and observed characteristics, the researcher conducted an in-depth analysis of Anjas to find the cause of the conflict. The following is an excerpt from an interview with Anjas.

- P : "In your opinion, is the formula you used to find the length of side PS from your answer correct or not?"
- Anjas : "Maybe that's true, ma'am."
- P : "But do you understand the Pythagorean theorem formula? How to find the hypotenuse?"
- Anjas : "I understand quite well, ma'am."
- P : "What is the formula?"
- Anjas : "The hypotenuse is equal to the height minus the flat side, ma'am."
- P : "But this time you do it in addition. So, subtract or add?"
- Anjas : "In addition."
- P : "For question number 1, you write $PS^2 = PQ^2 + RS^2$, did you realize that PQ and RS are not in the same triangle?"
- Anjas : "Yes ma'am, not in one triangle."
- P : "But you can use this formula why?"
- Anjas : "I don't know, ma'am."
- P : "This means that to find PS, use the height of side PQ?"
- Anjas : "Yes, ma'am."
- P : "So actually we use the height of the PR side to find the PS side. You should have found the PR side first."
- P : "Can you find the PS side? We already know how high the PR is. Can you do it?"
- Anjas : "I can't, ma'am, I'm confused about which side to enter into the formula."

When the interviewer directed Anjas to realize his mistake that he should have used PR as the high side in question number one, he experienced conflict. He was still confused and couldn't solve the problem, and admitted, "I can't do it, ma'am. I'm confused about which side to put into the formula."

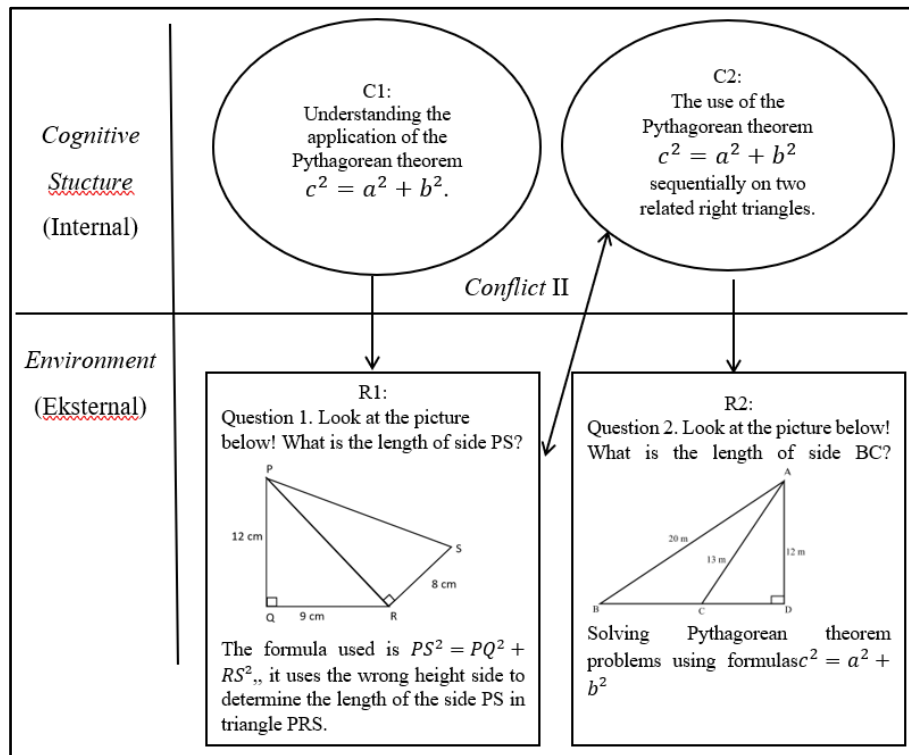


Figure 5. Type II Cognitive Conflict Diagram of Anjas

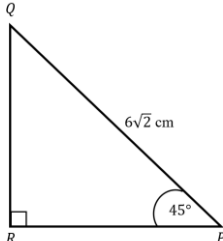
Accompanying physical symptoms included mumbling, frowning, lowering the head, and sighing, indicating cognitive frustration when trying to reconcile old procedures with new understanding. The confusion experienced by student Anjas showed that he was aware of the inconsistency between the new concept (C2) that he had regarding the application of the Pythagorean theorem formula to more complex flat shaped with the old, incorrect solution method (R1), which caused him to be unable to continue working on the problem correctly. Even, he had correct final result but the procedure was wrong. This indicates that Anjas experienced a type II cognitive conflict, namely between the new concept (C2) and the old environment (R1).

The Emergence of Type III Cognitive Conflict (Initial Concept vs New Concept)

Type III conflict predominantly appears in Problem 3 which requires the use of special right triangle ratios (45° - 45° - 90°). This problem triggers an internal

conflict between the general schema of the Pythagorean theorem and the specific schema of triangle ratios. The main obstacle is the internal conflict between the ingrained general schema of the Pythagorean theorem (C1) and the specific schema of special triangle ratios (C2) that has not been stably assimilated. Students experience conceptual confusion when they have to switch from a computational approach to a proportional approach. Four subjects experienced this conflict: Kayla, Roni, Kenzi, and Nayla. As a prime example, Roni demonstrated clear characteristics of conflict by insisting on the use of the general Pythagorean theorem for problems requiring an understanding of ratios.

3. Given a triangle PQR as shown in the picture. Determine the length of side PR!



$$RP^2 = 6\sqrt{2} - 45$$

$$= 12^2 - 45$$

$$= 144 - 45$$

$$= 99$$

→ The formula used is wrong.

→ The final result is wrong.

Figure 6. Roni's Answer to Question Number 3

Student Roni used the wrong formula to solve problem number three. He should have used the ratio formula for special triangles, but he didn't, so he didn't get the correct result. Based on the test results and observed characteristics, the researcher conducted an in-depth analysis of Roni to find the causes of type III conflict. The following is an excerpt from an interview with Roni.

- P : "Based on your answer, is number 3 right or wrong?"
 Roni : "Wrong ma'am."
 P : "Where is the wrong part?"
 Roni : "In the formula section, ma'am."
 P : "What formula do you use?"
 Roni : "Use the Pythagorean theorem comparison formula, ma'am."
 P : "The formula you used in number 3 is not the Pythagorean theorem comparison formula."
 P : "This is $6\sqrt{2}$. Do you know what the units are in the question?"
 Roni : " $6\sqrt{2}$ cm ma'am."
 P : "What is the unit for 45?"
 Roni : "Degree ma'am."
 P : "So because the units are different, $6\sqrt{2}$ cannot be operated with 45 degrees."
 P : "Do you remember the correct Pythagorean Theorem comparison formula?"
 Roni : "Forgot, ma'am."
 P : "If there is a question that worries you the most, which one is it and why?"

Roni : "Number 3, ma'am, because I don't know the formula."

In question number three, student Roni stated that the formula he used was the special right triangle formula. However, when the interviewer pointed out that it was not the correct comparison formula and asked again which comparison formula should be used, he said "I forgot ma'am", admitting that he did not know which formula should be used. This conflict arose when he realized that the units were different (centi-meters and degrees), and he could not operate with both values. This confusion was caused by two unsynchronized concepts, namely the concept of the ordinary Pythagorean Theorem that he was trying to apply (C1) and the concept of comparison of right triangles that should be used (C2).

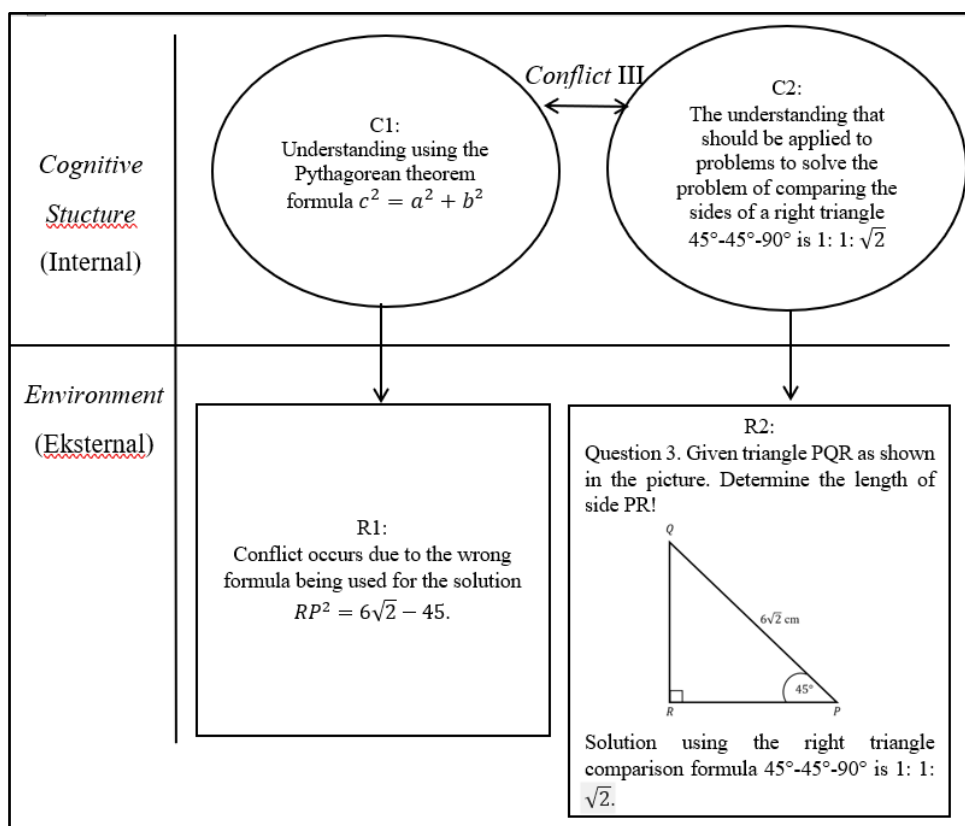


Figure 7. Type III Cognitive Conflict Diagram of Roni

Student Roni experienced a type III conflict when working on question number 3. Roni tried to use the Pythagorean Theorem formula that he knew (C1) to solve the question which actually required an understanding of the comparison of the sides of a special right triangle ($45^\circ-45^\circ-90^\circ$) (C2). Subject Kenzi experienced a more explicit conflict by using the reversed proportionality formula. She was aware of this error (the "reversed PR and QP formulas") but still could not determine the correct proportionality without the interviewer's help. These cases demonstrate a

struggle between two conceptual schemes in the students' cognitive structure, where the dominant old scheme inhibits the integration of the new, more specific scheme.

Discussion

Cognitive Conflict Type I: Failure of Assimilation in a New Environment

Type I conflict is defined as a conflict between the initial concept held by the student (C1) and the new environment (R2) which cannot be explained by C1 (Gyoungho & Jaesool, 2001, p. 6). In this study, R2 is a Pythagorean Theorem problem that requires students to deconstruct a geometric problem into two separate right triangles. Type I cognitive conflict is caused by students' inability to model non-routine geometric problems and misconceptions in identifying the hypotenuse. They try to fit complex problems into their memorized basic schema, which leads to misconceptions and anomalous results. Their existing basic schema cannot undergo conceptual change, and this condition results in cognitive conflict (Pratiwi et al., 2022a). Students like Kayla and Ahmad have mastered the basic Pythagorean theorem, but this scheme fails to assimilate to the new environment that demands the decomposition of geometric shapes. This failure is not simply a procedural error, but rather evidence of an inability to transform mental representations of verbal/visual problems into precise mathematical models.

This phenomenon aligns with Piaget's theory of failed assimilation, where existing schemas are unable to process new information, triggering intense disequilibrium. This cognitive tension manifests through physical symptoms such as head lowering and sighing, which indicate a state of cognitive imbalance (Putri & Adiputra, 2020). This finding strengthens (Pratiwi et al., 2022) research on routine errors that trigger cognitive conflict when students are faced with non-routine problems. As in that study, the subjects in this study are shown to overgeneralize basic schemas to inappropriate contexts.

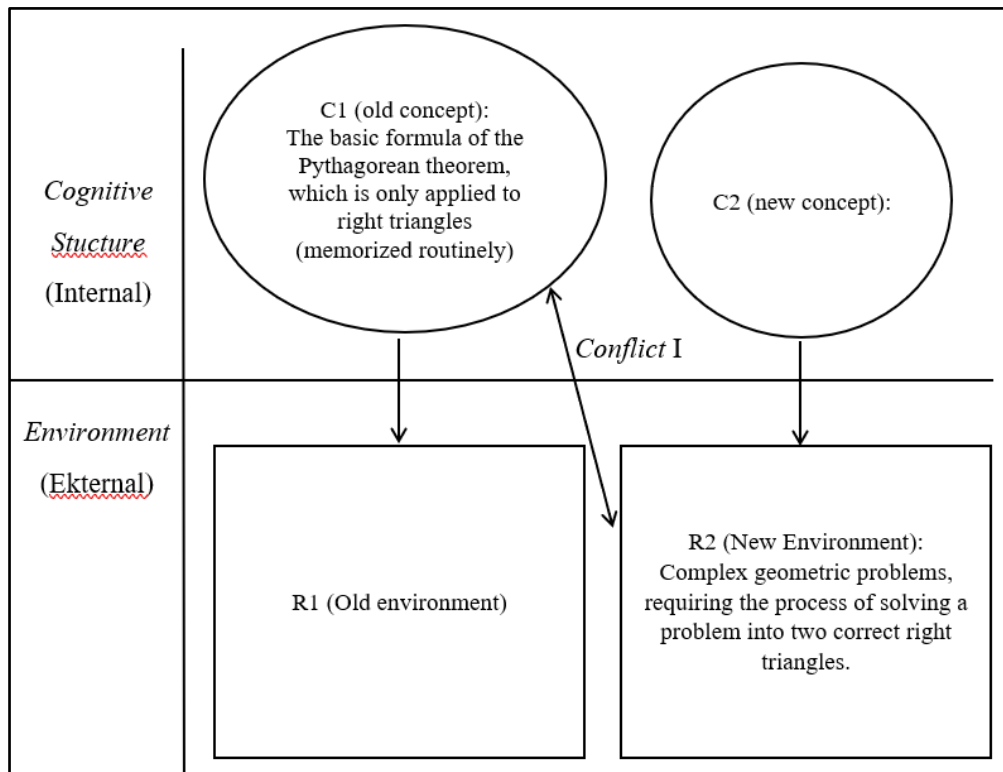


Figure 8. Type 1 Cognitive Conflict Diagram

The emphasis of learning should be directed toward strengthening visual-geometric understanding through manipulatives and non-routine problem-modelling exercises. Teachers are advised to provide scaffolding in identifying geometric components and transforming them into appropriate mathematical models.

Cognitive Conflict Type II: Dominance of Procedural Habits Over Conceptual Understanding

Type II conflict occurs when the concept to be learned (C2) conflicts with the old environment (R1) which often takes the form of erroneous thinking habits or procedures dominated by old schemes (Gyoungho & Jaesool, 2001, p. 6). Anjas was the only subject identified as experiencing this type of conflict. Anjas demonstrated an interesting pattern in question two. He successfully obtained the correct answer (BC = 11 meters), but his initial procedural steps were incorrect, using an inappropriate side to find the required side length.

Anjas' Type II conflict reveals a complex epistemological phenomenon, where faulty procedural habits (R1) dominate correct conceptual understanding (C2). "Haphazard" success in obtaining the correct answer actually becomes a conceptual barrier, as it provides negative reinforcement for the incorrect method.

Students are trapped in a state of pseudo-confidence where they feel no need to revise their schema even though it is conceptually fragile. This configuration is consistent with the model (Gyoungho & Jaesool, 2001) regarding C2 vs R1, where new concepts are unable to replace old thinking habits. The dominance of R1 creates a cognitive trap that hinders conceptual restructuring.

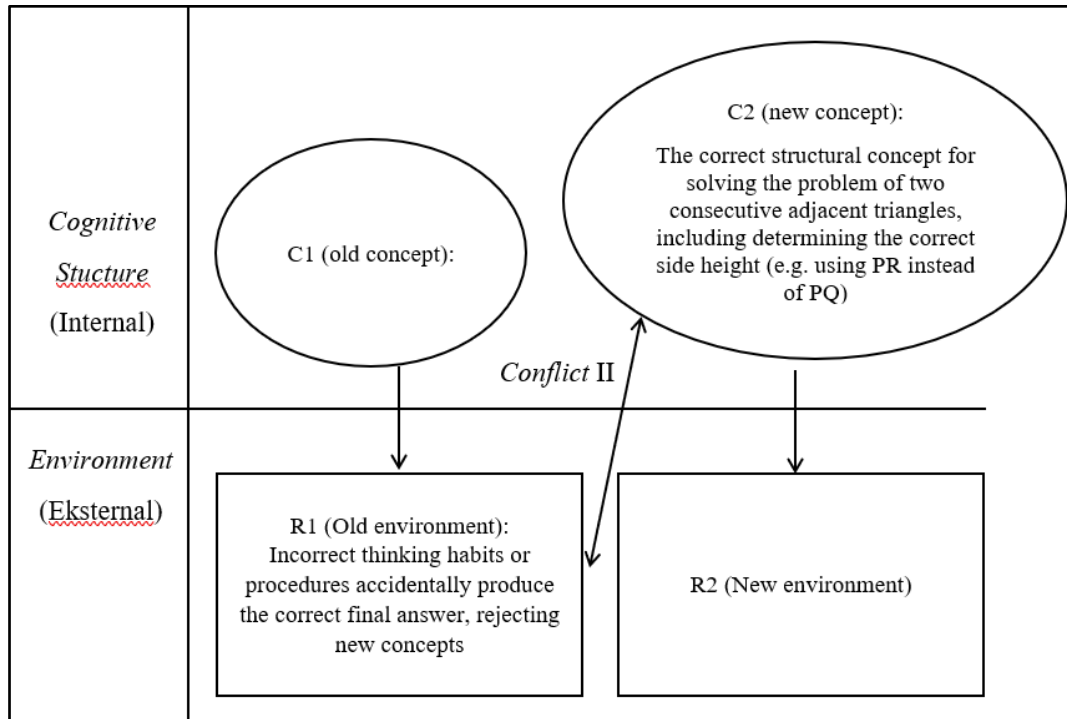


Figure 9. Type II Cognitive Conflict Diagram

Teachers need to shift from focusing on final answers to analysing thought processes. Cognitive conflict induction strategies can be implemented by deliberately presenting contradictions between incorrect methods and conceptual understanding, so that students recognize the need to revise their schemas.

Cognitive Conflict Type III: The Internal Struggle Toward Accommodation

Type III conflict represents the most profound internal struggle, where the general schema of the Pythagorean theorem (C1) and the specific schema of the special triangle ratio (C2) compete for dominance within the cognitive structure. The failure of subjects like Roni and Kenzi to access C2 indicates that the concept of ratio has not been stably accommodated, and is thus suppressed by the more dominant general schema. This situation reflects Piaget's inhibited accommodation process, where revision of the fundamental schema does not occur due to the instability of the new concept. As stated by (Marinda, 2020), accommodation requires a total revision of the old scheme to accept the new concept, which in this case failed

to be actualized. This finding is in line with (Lestary et al., 2022) about cognitive conflict in the concept of ratio, where students have difficulty integrating proportional understanding with other mathematical concepts.

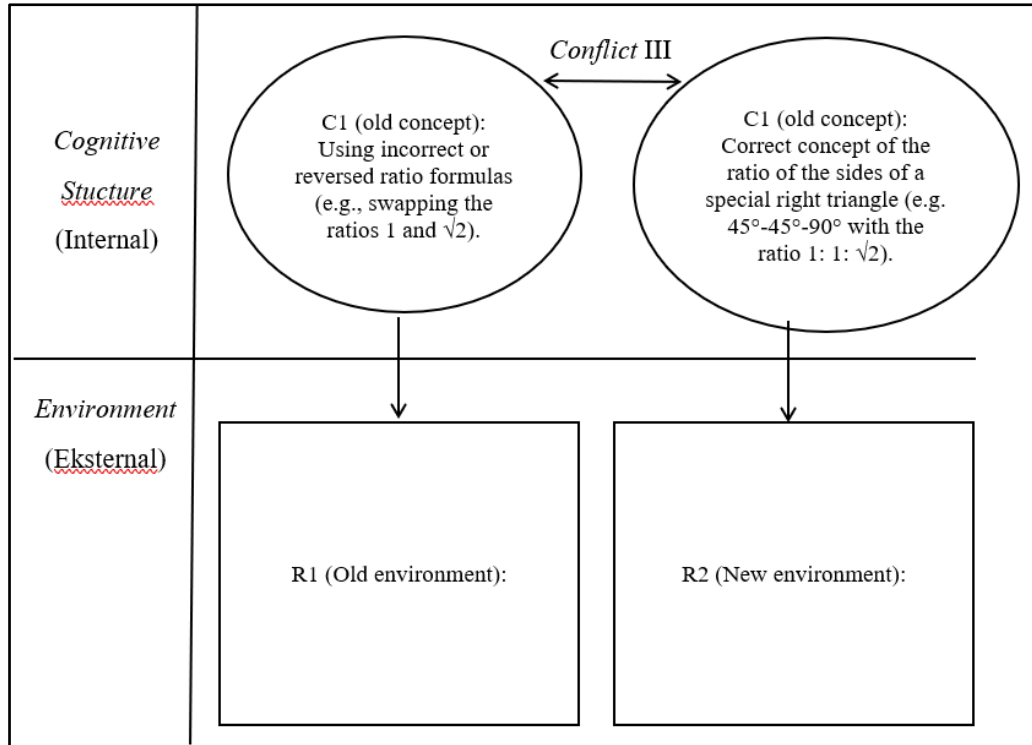


Figure 10. Type III Cognitive Conflict Diagram

Intensive contextual practice on special triangles is required until the ratio scheme becomes automatic and equal in power to the general Pythagorean scheme. Learning should emphasize building strong conceptual connections between various mathematical representations.

Synthesis of Findings

The three types of cognitive conflict represent a comprehensive spectrum of learning barriers. Type I indicates assimilation failure at the problem modelling level, Type II reveals procedural dominance over conceptual, and Type III represents accommodation struggles at the conceptual schema level. Each type requires a different and specific pedagogical approach. This study successfully maps the specific manifestations of Pythagorean misconceptions into Kwon and Lee's theoretical framework of cognitive conflict, a practice rarely undertaken in previous research. This mapping provides a more precise diagnostic basis for identifying the roots of students' cognitive problems, while also providing a framework for

developing more targeted and effective learning strategies to overcome conceptual barriers to mathematics learning.

Conclusion

This exploratory case study successfully describes the types of cognitive conflicts experienced by junior high school students in solving Pythagorean Theorem problems, confirming the emergence of Type I, Type II, and Type III Conflicts. Type I Conflicts are primarily triggered by structural and visual-geometric misconceptions, where students fail to model non-routine problems and misidentify the hypotenuse, resulting in anomalous results that challenge their initial beliefs. Type II Conflicts are a manifestation of epistemological barriers caused by the dominance of erroneous procedural habits, which are maintained despite students having the potential to activate the correct concept. Meanwhile, Type III Conflicts indicate a purely internal conflict between the general conceptual schema of the Pythagorean Theorem and a specific conceptual schema (special triangle ratios) that has not been stably assimilated.

The pedagogical implications of these findings are significant. Given that Type I is rooted in weaknesses in geometric visualization, instruction needs to explicitly emphasize the flexibility of modelling and determining the hypotenuse across orientations. To overcome Type II resistance and Type III internal struggles, teachers are advised to adopt a deliberate cognitive conflict learning strategy. Teachers should intentionally create disequilibrium (e.g., by presenting contradictory evidence or anomalous results) to force students to accommodate schemas, rather than simply passively assimilate them. By encouraging this cognitive restructuring process, teachers can facilitate a more stable transition from misconceptions to accurate conceptual understanding.

The limitations of this research lie in its nature as a qualitative exploratory case study, so the results can only provide in-depth understanding of the context of the subjects studied and are not intended to be generalized to a broader population. Furthermore, this research focused on conflict identification and did not include the design of conflict-based interventions for direct misconception resolution.

References

- Gyoungho, L., & Jaesool, K. (2001). What Do We Know about Students' Cognitive Conflict in Science Classroom: A Theoretical Model of Cognitive Conflict Process. *AETS Annual Meeting*, 309–325.

- Hidayah, A., & Maemonah, M. (2022). Analisis Hambatan Belajar Siswa Kelas IV Pada Mata Pelajaran Matematika. *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, 7(2), 232–240. <https://doi.org/10.23969/symmetry.v7i2.6737>
- Hidayah, N., & Hasanudin, C. (2024). Penerapan teorema pythagoras dalam kehidupan sehari-hari. *Prosiding Seminar Nasional UKM Penalaran Dan Riset IKIP PGRI Bojonegoro*, 2(1), 58–67.
- Ifada, R. B., & Ruli, R. M. (2024). Hambatan Belajar Siswa Sekolah Menengah Pertama (SMP) pada Materi Teorema Pythagoras. *PHI: Jurnal Pendidikan Matematika*, 8(1), 114. <https://doi.org/10.33087/phi.v8i1.362>
- Indrawati, N., Nuramilan, N., & Amin, N. (2024). Analisis Kesulitan Siswa dalam Memecahkan Masalah Teorema Pythagoras. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 4(1), 640–649. <https://doi.org/10.51574/kognitif.v4i1.1421>
- Kemendikbudristek. (2023). Pisa 2022 dan Pemulihan Pembelajaran di Indonesia. *Laporan Pisa Kemendikbudristek*, 1–25.
- Lee, Y., & Kwon, J. (2002). The Effects of Cognitive Conflict on Students' Conceptual Chang. In *Journal of the Korean Association for Research in Science Education* (Vol. 22, Number 5, pp. 923–943).
- Lestary, R., Subanji, S., & Ramadani, I. (2022). Cognitive conflict of relational learners in connecting proportion concepts on three term Rrtio problems. *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, 6(2), 129–140.
- Marinda, L. (2020). Teori Perkembangan Kognitif Jean Piaget Dan Problematikanya Pada Anak Usia Sekolah Dasar. *An-Nisa': Jurnal Kajian Perempuan Dan Keislaman*, 13(1), 116–152. <https://doi.org/10.35719/annisa.v13i1.26>
- Novianda, D. (2022). Analisis Hambatan Belajar (Learning Obstacles) Dalam Pembelajaran Geometri: Literatur Review. *Jurnal Gantang*, 6(2), 133–139. <https://doi.org/10.31629/jg.v6i2.2866>
- Pratiwi, E., Nusantara, T., Susiswo, S., & Muksar, M. (2022a). Routines' errors when solving mathematics problems cause cognitive conflict. *International Journal of Evaluation and Research in Education*, 11(2), 773–779. <https://doi.org/10.11591/ijere.v11i2.21911>
- Pratiwi, E., Nusantara, T., Susiswo, S., & Muksar, M. (2022b). Routines' errors when solving mathematics problems cause cognitive conflict. *International Journal of Evaluation and Research in Education*, 11(2), 773–779. <https://doi.org/10.11591/ijere.v11i2.21911>
- Putri, H. E., & Adiputra, Y. (2020). Penerapan Strategi Konflik Kognitif Untuk Meningkatkan Kemampuan Pemahaman Matematis Taruna Akademi Maritim Cirebon. *GAUSS: Jurnal Pendidikan Matematika*, 03(02), 32–42.
- Sari, Herdita, P., Fuadiah, N. F., R. (2021). *Desain Didaktis Hipotetik Pembelajaran Teorema Pythagoras*. 1(2).