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Decompose The Cognitive Mapping of The PISA Question's Problem Solving Thinking Structure

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Abstract: The mistake in problem-solving indicates the presence of the cognitive structure parts, which are problematic. One of the causes is thinking structures that need to be better organized and connected or experience cognitive mistakes. This study aims to describe students' thinking structure mistakes in solving PISA questions and the efforts to correct these mistakes through defragmenting thinking structures. This study uses a qualitative approach. This study uses a qualitative approach, including data reduction, presentation, and conclusion. Based on the results of the study, the mistakes of the students' thinking structures in problem-solving to finish the PISA questions were experienced by all subjects, including students misunderstanding the problem, mistakes in devising a finishing plan, carrying out a finishing plan, and rechecking process. These mistakes are influenced by several reasons, including the need for literacy skills in reading the meaning of the questions, not focusing on essential instructions on the questions, mastery of understanding the concept of prerequisite material, mistakes in operating, and the structured and analysis errors. The defragmenting process is carried out to correct students' thinking structure mistakes in problem-solving through intervention processes including scaffolding-review, scaffolding-restructuring, scaffolding-explaining, cognitive conflict, and dis-equilibration.

Keywords: defragmenting, problem, question, structure, solving, thinking

Abstrak: *Kesalahan dalam pemecahan masalah menunjukkan adanya bagian-bagian struktur kognitif yang bermasalah. Salah satu penyebabnya adalah struktur berpikir yang perlu ditata dan terhubung dengan baik atau mengalami kesalahan berpikir. Penelitian ini bertujuan untuk mendeskripsikan kesalahan struktur berpikir siswa dalam menyelesaikan soal PISA dan upaya memperbaiki kesalahan tersebut melalui defragmentasi struktur berpikir. Penelitian ini menggunakan pendekatan kualitatif. Adapun pendekatan kualitatif yang meliputi reduksi data, penyajian, dan penarikan kesimpulan. Berdasarkan hasil penelitian, kesalahan struktur berpikir siswa dalam pemecahan masalah hingga menyelesaikan soal PISA dialami oleh semua mata pelajaran, antara lain siswa salah memahami soal, kesalahan menyusun rencana penyelesaian, melaksanakan rencana penyelesaian, dan proses pengecekan ulang. Kesalahan tersebut dipengaruhi oleh beberapa hal, antara lain perlunya kemampuan literasi dalam membaca makna soal, tidak fokus pada petunjuk esensial soal, penguasaan pemahaman konsep materi prasyarat, kesalahan pengoperasian, serta kesalahan terstruktur dan analisis. Proses defragmenting dilakukan untuk memperbaiki kesalahan struktur berpikir siswa dalam pemecahan masalah melalui proses intervensi meliputi scaffolding-review, scaffolding-restructuring, scaffolding-explaining, kognitif konflik, dan dis-equilibration.*

Kata kunci: *defragmentasi, masalah, pertanyaan, struktur, pemecahan, pemikiran*

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▪ INTRODUCTION

The openness of information and knowledge marks the 21st century, the availability of various alternatives to facilitate global community life, and the existence of competition fundamentally in various human life systems. Education has become one of the sectors which get great demand. Consequently, education faces the demands of the importance of quality and competitive human resources at the global level. One of the efforts to face this challenge is to improve the quality of learning and the era's demands.

The partnership for 21st-century skills states that the 21st century should focus on elaborating the 4C as the output of learning skills, including; Critical thinking, Communication, Creativity, and Collaboration. Among the subjects taught in schools, one considered to achieve these criteria at school is mathematics (Teresa, Zubaidah, & Nursangaji 2020). In this highly dynamic world, people who understand and commit to math are significantly more likely to reach their future (NCTM 2000). Mathematical competence allows someone to open the door to a more productive future. However, if mathematical competence is low, it can close the door to future opportunities (Allen et al. 2020). Therefore, mathematics competence must be mandatory in learning at every level of education.

The importance of mathematical competence is still in line with the quality and achievement of mathematics education in Indonesia. The result of an international standard assessment organized by the organization for economic co-operation and development (OECD) is called the program for international student assessment (PISA) (OECD 2019). PISA measures the children's mathematical literacy skills aged 15 years in OECD participating countries. The PISA questions criteria involve several processes, including analysis, reasoning, and communication (OECD 2019). The processing steps are: formulating mathematical situations, applying mathematical concepts, facts, procedures, and reasoning, and interpreting solutions to mathematical problems in various situations. This aims to measure how far the students' abilities and knowledge in understanding the application and benefits of mathematics contribute to daily life.

The results of the PISA assessment show that the achievement of students' mathematical literacy in Indonesia from previous years still needs to be higher. For example, in 2009, Indonesian students were ranked 61 out of 65. In 2012, they were ranked 64 out of 65. In 2015, they were in position 63 out of 70; in 2018, they were in position 72 out of 77 OECD participating countries (OECD 2019).

Some conditions of the students' mathematical literacy in Indonesia still need to improve. Therefore, they need help in working on PISA questions. One of the causes of students' difficulties in committing PISA questions is that the mathematical reasoning activities in solving the questions on the content of numbers (quantity) need to be more familiar. The ability of students in this content still needs improvement. Only a few students can use mathematical reasoning well to answer the questions (Jose M Ocampo 2018).

There are three student mistakes when committing to PISA questions with change and relationship content, namely the mistakes in understanding the questions, changing the problems in the questions to mathematical form, and writing or concluding the final results. These difficulties arise due to low mathematical reasoning (Pranitasari and Ratu 2020). One of the biggest failures of students in committing to PISA questions is when students obtain the mathematical results, then proceed to the stage of interpreting the answers into the desired situation/context (Irhamna, Amry, & Syahputra 2020; Tohir et al. 2020). From the description of these findings, most students' difficulties in committing PISA questions are caused by their low mathematical reasoning ability.

Mathematical reasoning is related to students' ability to connect problems to an idea so they can solve mathematical problems (Irhamna et al. 2020). This ability can be interpreted as a thinking process in giving conclusions about problems by connecting mathematical knowledge with existing problems in the form of ideas so that they can be solved in mathematical models. This mathematical reasoning ability becomes the cause of students' difficulty in relating their mathematical knowledge to solving problems on the given PISA questions. This can happen because th\ere is no match between the structure of students' thinking and the problem at hand (Saad 2020). The thinking process is determined by evaluating the thinking structure of the problem at hand.

Due to the inability to reason mathematically in committing to PISA questions, students need to gain an understanding of mathematical concepts. The process of mathematical reasoning expresses that this requires a strong understanding of the various concepts of the given problem (Nurdin, Samad, and Sardia 2020; Sulistyo, Sukestiyarno, and Mastur 2021). The lack of understanding of concepts often encourages students to think pseudo-thinking, namely experiencing dependence on problem-solving procedures taught previously to encourage looking for similar examples of questions when committing to the given questions (Roe, Blikstad-Balas, & Dalland 2021). If the questions given are the same as those that the students have committed, but if the questions given are slightly different from those given, the students will need help answering them.

The concepts in mathematics are a connected unit, having a relationship between one concept and another in a complex, structured, and systematic way so that it requires a mathematical connection to understand it (Pratiwi, Inganah, & Putri 2020). Mathematical connections are part of a network of interconnected knowledge packages containing key concepts. Students can use them to understand and develop relationships between facts, mathematical ideas, concepts, and procedures (Prayitno 2018). Without a mathematical connection, the students will tend to feel that mathematical concepts are numerous and difficult to learn and understand.

The mathematical connection ability includes the relationship between mathematical topics or materials and mathematics with other fields of science and everyday life (Hadiat & Karyati 2019). There is a close relationship between the ability of mathematical connections to the ability to reason mathematically. This statement is supported by research that states the relationship between mathematical connection abilities and reasoning abilities, with a contribution of 23.27% (Bernard and Setiawan 2020).

Mathematical concepts and connections can be improved by arranging the mathematical thinking structure, known as mathematical defragmenting (Surya & Syahputra 2017). The term was first used in Information Technology, which is defined as the arrangement or repair of damaged file space on a computer due to fragmentation (split, scrambled, disorganized) into a single block of files so that the computer can operate quickly without damaging the stored files. In education, this term is used to organize and improve the students' thinking structure. Defragmenting can also be interpreted as cognitive restructuring in an individual (Ena 2020).

Defragmenting is more about changing the students' thinking structure. The students are taught to change their thinking mistakes to become realistic. This method can also accelerate the student learning process toward discovering more scientific concepts (Subanji 2016). So that through the process, incorrect mathematical reasoning will be rearranged to become correct.

The success of this process is highly dependent on the intervention given by other people. Several ways of intervention in defragmenting thinking structures include scaffolding, cognitive conflict, and dis-equilibration (Haryanti 2018). Dis-equilibration is committed by asking mistrust questions so that students commit the reflection process on the answer. Cognitive conflict is committed to the students when they experience mistakes that require examples to be used for conflict so they will finally rethink their answers. Finally, scaffolding is an effort to assist students with questions, instructions, reminders, directions, or encouragement when they experience mistakes in solving problems (Kumalasari, Nusantara, & Sa'dijah 2016).

In the PISA questions, as described previously, the students' average mistake occurs due to the lack of reasoning ability, which can be caused by weak mathematical concepts and connections and strategies in solving mathematical problems in the questions (Özcan and Doğan 2018). Therefore, the intervention can be carried out in two stages: intervention on conceptual mistakes and mathematical connections and intervention on strategic mistakes in solving problem-solving (Katrancı and Şengül 2020). Unfortunately, some studies presented above have not yet detailed and identified how students' thinking structure mistakes in solving problems to commit PISA questions. Therefore, management interventions should also be given by identifying thinking structure mistakes.

Defragmenting in committing PISA problems can use cognitive mapping. Ackerman suggests that cognitive mapping can be used in various ways, among others, to solve problem-solving either individually or in groups. This technique can make solving problems easier and create the problem structure to be solved (Aidossov, Aidosov, & Narbayeva 2021). Besides that, according to Abadi, the most important thing is that cognitive mapping will make it easier to formulate the difficulties experienced by students and determine the appropriate steps for assistance efforts (Kim, Belland, & Axelrod 2019).

Based on the problem above, the problem statement from this research can be stated as follows: How is the description of students' thinking structure mistakes in solving problems on PISA questions? How is the defragmenting of problem-solving thinking structure through cognitive mapping based on Polya's theory on PISA questions?

▪ METHOD

Research Design and Procedures

This study seeks to reveal deeply the process description of defragmenting of problem-solving thinking structure through cognitive mapping based on Polya's theory on PISA questions. According this kind of research is classified as qualitative research. This research emphasizes the process analysis of observation activities in locations where various facts, data, or other matters related to the dynamics of the relationship between observed phenomena and thinking based on the reality or circumstances that occur, as well as examining various studies and collections of various types of empirical material, such as case studies, personal experiences, introspective confessions, life stories, interviews, talks, photography, recordings, personal notes, and various other visual texts.

Participants

The subjects of this study were 15-year-old high school students in Parepare City who were selected using a purposive sampling technique. From 35 students, three students were selected based on the level of students' ability to solve problems (good, moderate, and less, one person each) as well as students' communication skills so that the disclosure of the completion process can be carried out properly.

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Instruments and data analysis

The main instrument in this research is the researcher. In this case, the researcher is the planner, the implementer of data collection and analysis, the data interpreter, and the pioneer of research results. The test questions used in this study were PISA questions taken through the official page https://www.oecd.org/pisa/ and then developed by the researchers themselves. First, however, the research instrument needs to be validated by experts to adjust to the research concept. The validation criteria carried out include Items following the research concept, namely problem solving, Items formulated, communicative sentences and standard language, and Sentence structure is not multiple interpretations.

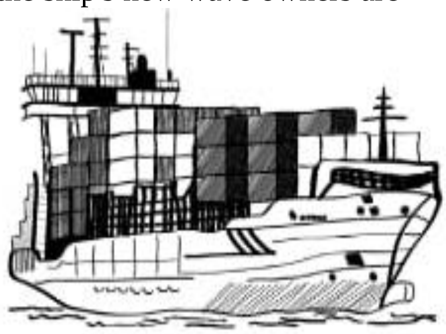
Interview Guidelines: The interview is unstructured because the questions are developed based on the respondents' unique circumstances and characteristics. The interview guide developed by the researcher is the basic questions to describe the students' thinking structure mistakes in solving problems. However, the research instrument needs to be validated by the experts first. The validation criteria carried out include The suitability of the interview questions with the purpose of the interview, The questions used are appropriate to understand the student problem-solving framework based on Polya's theory, The interview questions are easy to understand, The language used does not contain multiple meanings, The purpose of the question is formulated briefly and clearly.

▪ RESULT AND DISSCUSSION

Before the test, the researcher reflected on the studied mathematical material, which was adjusted to the indicators in the PISA math questions to be tested. Then, the researcher gave 5 test questions which two expert lecturers validated. The valid PISA math test questions are as follows:

Number 4

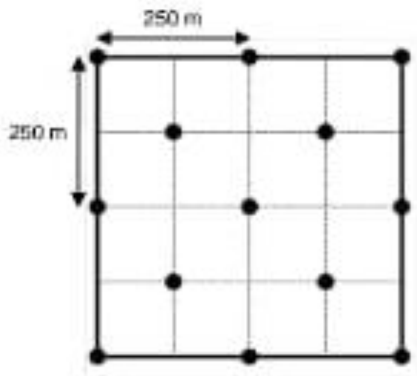
Due to high diesel fuel costs of 0,42 zeds per liter, the ship's new wave owners are considering equipping their boat with a kite sail. A kite sail like this has the potential to reduce diesel consumption by about 20% overall.



Name: New Wave
Type: Freighter
Length: 117 meters
Breadth: 18 meters
Load capacity: 12.000 tons
Maximum capacity: 19 knots
Diesel consumption per year without a kite sail: approximately 3.500.000 liters

Number 5.

Zedtown has erected some E-82 wind power stations in a square field. (length = breadth = 500 m). According to building regulations, the minimum distance between the power of two wind power stations of this model has to be five-time times the length of a rotor blade.



The town mayor has suggested arranging wind power stations in the field. This is shown in the diagram opposite.Explain why the town mayor's suggestion fails to meet the building regulations. Then, support your arguments with calculations.

Note: Drawing is not to scale = wind power station tower

Through these questions, the researcher designed a cognitive map based on Polya's theory that describes a series of cognitive structures passed in solving questions to facilitate the mistakes in thinking structures in solving the questions. For example, the following is a cognitive mapping based on Polya's theory on questions 4 and 5.

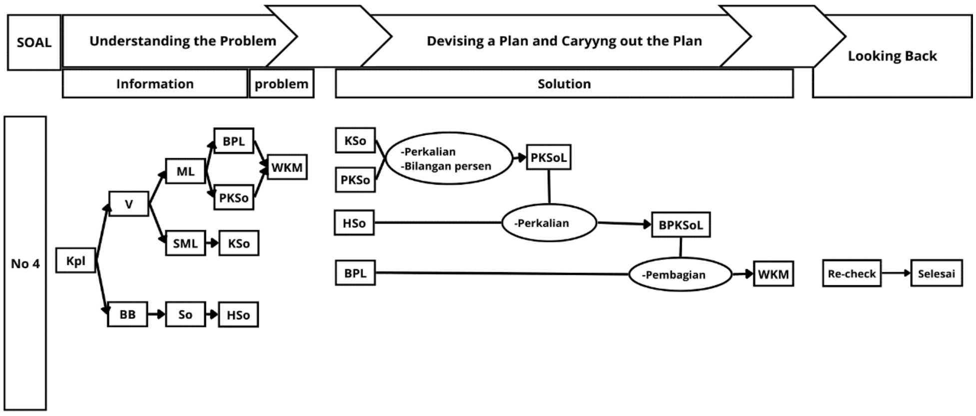


Figure 1. Cognitive mapping based on polya's theory in test number 4

The explanation of each code is as follows: new wave boat (Kpl), Boal version (V), the new wave boat version uses sails (ML), new wave boat version before using sails (SML), boat fuel (BB), diesel (So), screen installation fee (BPL), annual solar savings after screen installation (PKSo), diesel consumption per year (KSo), diesel consumption saved per year (PKSol), the cost of solar consumption is saved per year (BPKSol), the time it takes cost savings during screen installation to cover the cost of screen installation (WKM), price of diesel per liter (HSo), recheck answers (recheck), and done (salesai)

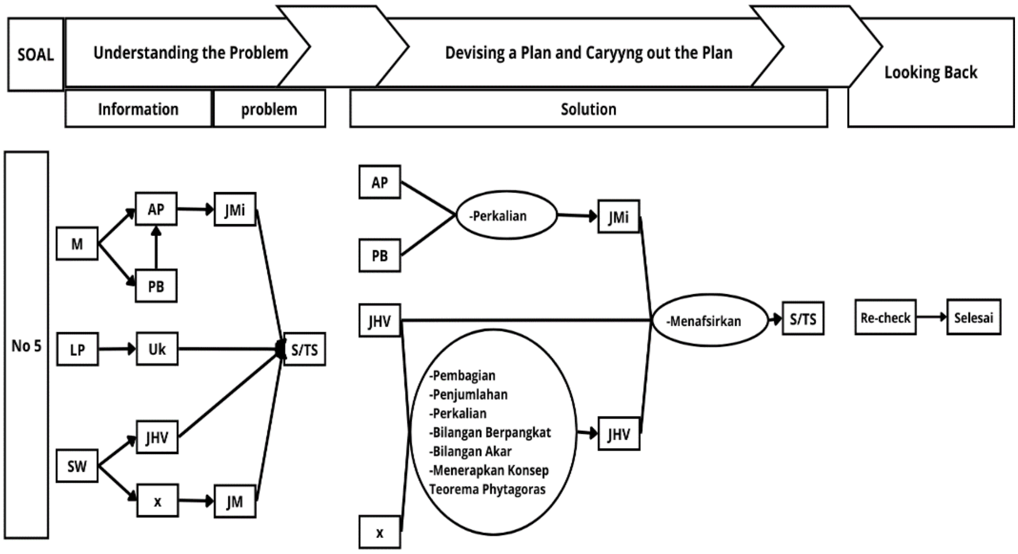


Figure 2. Cognitive mapping based on polya's theory in test number 5

The description of each code is as follows: Power plant tower (M), power plant tower construction site (LP), Mayor's advice regarding the construction of a power plant tower (SW), Power plant tower propeller length (PB), distance horizontal and vertical between 2 power plant towers (JHW), Cross distance between 2 power plant towers (X), power plant tower construction rules (AP), crossover distance between 2 power plant towers (JM), Status statement (S/TS), recheck answers (Recheck).

The following will describe the data obtained from research activities and research subjects. The data used in this study is from test results carried out by students and researchers with interview data with research subjects. The two data will be the benchmark for defragmenting given to students to overcome students' thinking process mistakes when solving tests in PISA mathematics.

Data Description of Students' Thinking Structure Mistakes in Solving PISA Math Test

Based on the results of the examination through the answer sheet and the interview process, three different research subjects were obtained: students with the lowest mistake and communicative subject 1 (S1), students with moderate and communicative mistake subject 2 (S2), and students with the greatest mistakes and communicative subject 3 (S3). The description of mistake data for each subject is described as follows. Subject 1 (S1). The following describes the answer to S1 in question Number 4

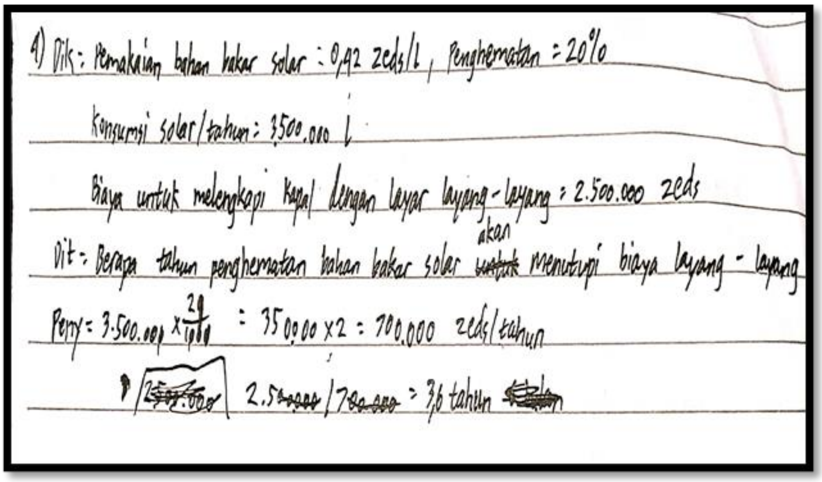


Figure 3. The mistake of s1 in test number 4

Based on the written answers above, S1 can write down what is known and asked in the question using understood language. Furthermore, during the interview, S1 was very fluent and explained the information in the questions and problems. This shows that the S1 thinking structure is clear and structured in understanding the problem. However, when the researcher observed closely the answer sheets that were made, the completion mistake was seen when S3 wrote down the division of the cost of installing kites with diesel consumption/year to produce the time required for saving using kite sails so that they could cover the installation costs.

The following is an excerpt from an interview that clearly shows the mistake.

P : How do you solve/resolve the problem?

S1 : (Thinks for a moment) Look, Sis/Bro, we know the savings is 20%. So I multiplied that by 20% with the original annual expenditure of 3,500,000. The result is 700,000 zeds per year.

P : 700,000 zeds per year. What does that mean?

S1 : The price of fuel per year is.

P : What is the difference between this 700,000 and 3,500,000

S1 : Oh, this means 700,000 zeds per year, the cost savings when using a kite. After that, the question is how many years of saving diesel fuel so that it can cover the cost of the kite. That's why I divided 2,500,000 zeds by 700,000 zeds per year. Each zeds unit is removed, so the result is 3.6 years.

P : Are you sure about your answer?

S1 : Sure, sis/bro.

P : Have you double-checked before?

S1 : Yes, sis/bro)

From the quote above, it can be seen that in solving the problem in question Number 4, S1 intends to start by calculating the cost of fuel saved for one year if using a kite sail, after that S1 will continue by calculating the length of time it will take to cover kite costs. However, when S1 calculates the cost of fuel saved for one year, S1 divides the amount of diesel consumption per year without a kite by the percentage of savings on a ship with a kite. The results obtained are not fuel costs saved for one year but the amount of fuel consumption saved for one year. This mistake occurs because it needs to pay attention to the units of numbers operated on. As a result, when continuing to complete the calculation of the length of time needed to cover the cost of the kite, what is committed is instead of dividing the cost of kite installation by the cost saved per year, S1 divides the cost of installing the kite by the amount of fuel saved for 1 year.

Based on the analysis of Polya's problem-solving theory, it can be concluded that S1 can understand what information is known and what is asked by the questions well but has a mistake in compiling a settlement plan due to a lack of mathematical concept reasoning. The following is a description of the mistake data on the structure of thinking in the form of cognitive mapping based on Polya's theory.

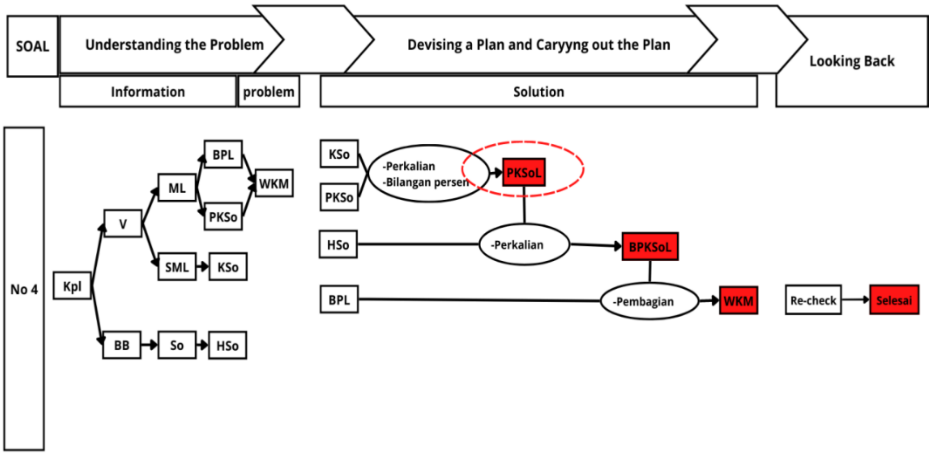


Figure 4. Cognitive mapping analysis of s1 mistakes in test number 4

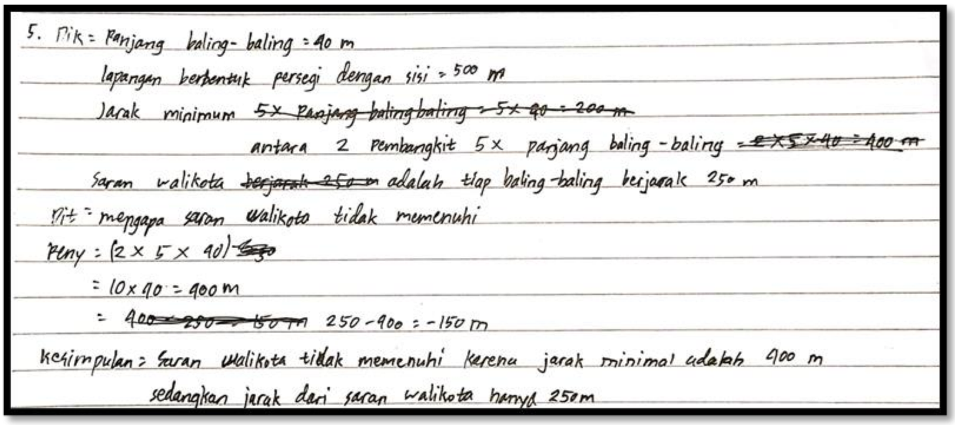


Figure 5. The mistake of s1 in test number 5

Based on the written answers above, it can be seen that S1 wrote down some of the information that was known and asked about in the questions using understandable language. However, based on the comparison of written answers and conversations through interviews, it is known that S1 still needs to be suitable for understanding the information from the questions. These mistakes occur when the researcher observes and asks about the completed steps.

The following is the interview that describes the mistake.

P : Okay, if that's the question, how did you solve it?
S1 : (Thinks momentarily, remembering what he wrote) What formula do I use?
P : I also need clarification to read it. What does 2 x 5 x 40 meters mean?
S1 : Ee...First, right before 5 x 40 is the minimum distance between the power plant towers. Here, I have doubled it because there are two power plants.
P : what do you mean?
S1 : There are two power plants, for example, 200 only, the propellers.
P : According to the S1 regulations, the distance from the building is 400 meters.
S1 : yes 400

From the quote above, it is clear that S1 needed help understanding the meaning of one of the question sentences. Then, finally, S1 understands the sentence "The minimum distance between 2 wind power generation towers of this model must be five times the length of the propeller," meaning that each propeller has a distance of 200 meters so that S1 obtains the distance between the propellers of one another, which is 2 x 200 meters or equal to 400 meters, from now on referred to as the purpose of the building rule.

Misunderstanding the meaning of the sentence caused the wrong solution. S1 concluded by comparing the 250 meters distance from one of the distances suggested by the Mayor in the picture with the 400 meters building rules. It concluded the answer by only comparing 250 with the Mayor's rule, showing that the information in the picture suggested by the Mayor on the question needs to be fully understood. S1 only sees what has been presented in the picture and ignores other important things in the picture of the question.

Based on the analysis of Polya's problem-solving theory, it can be concluded that S1 needs to be corrected in understanding the information about the problem due to the lack of S1 literacy in reading the questions. First, students need to be able to focus on the intent of the story. The second cause occurs because they only focus on what has been presented in the picture and ignore other important things. The following is a description of the data on the structure of thinking mistakes in the form of cognitive mapping based on Polya's theory.

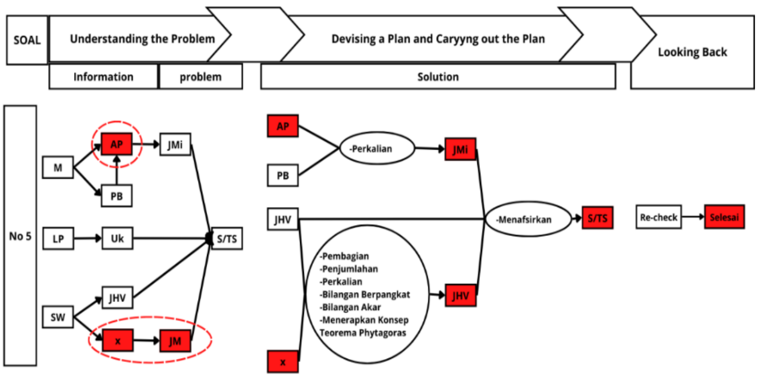


Figure 6. The cognitive mapping analysis of s1 mistakes in test number 5

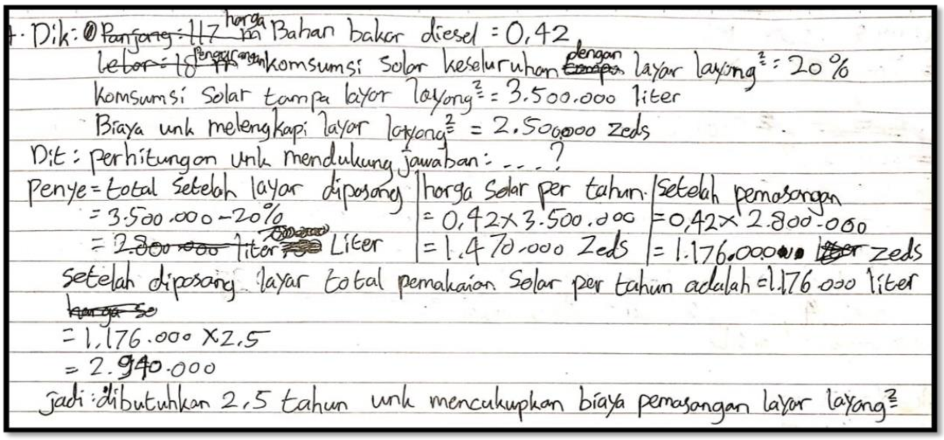


Figure 7. The mistake of s2 in test number 4

Based on the written answers above, it can be seen that S2 can write down what is known and asked in the question by using understood language even though it is incomplete. Still, during the interview, S2 could fluently explain the information in the question and the problems given. This shows that the S2 thinking structure is clear and structured in understanding the problem. However, the mistake is seen. When the researcher observes the completion steps made, the calculation operation needs to be corrected. S2 uses the subtraction operation to find the large savings in diesel consumption when using a kite sail. In addition to these mistakes, the solutions made were incorrect, so the final answer needed to be corrected.

The following is an interview that describes S2's thinking mistakes:

P : Can you explain the solution, bro?

S1 : (Explaining the meaning of the writing slowly) Eee. First, that's the total fuel consumption after using the kite sail, and I got from 3,500,000 litres. I subtracted it by 20%. So the result is 2,800,000 litres. Then to find the cost savings after installing the kite sail, I multiplied 2,800,000 litres by 0.42 zeds. The result is 1,176,000 zeds. Then 1.176.000 multiplied by 2.5 years, the result is 2.940.000. So it takes about 2.5 years to cover installing the kite.

P : Where did the 2.5 come from?

S1 : I'm guessing, Bro, how many years will it cost after installation so that it can cover the cost of installing the kite screen?

From the quote above, it is clear that the rarity carried out by S2 contains operations and a settlement plan that needs to be corrected. In the initial step taken, S2 started by finding the ship's total fuel consumption after installing the kite sail through an incorrect operating symbol. When calculating the initial consumption reduction with a 20% discount percentage, S2 described it by writing 3,500,000-20 %. In addition, in the next step, S2 looks for the cost of diesel consumption after saving by multiplying the cost of diesel per unit, which is 0.42 zeds with the total fuel consumption of the ship after installing the kite sail of 2,800,000 litres so that it is obtained 1,176,000 litres. To get the final answer, Masters concludes that the cost savings will cover the cost of installing a kite after 2.5 years by guessing a number that can multiply 1,176,000 to produce a number that can exceed the cost of installing a kite of 2,500,000 zeds. Clearly shows a fatal mistake in the final settlement plan made.

Based on the analysis of Polya's problem-solving theory, it can be concluded that S2 can understand what information is known and what is asked by the questions well. However, S2 experienced a mistake in formulating a problem-solving plan due to a lack of mathematical concept reasoning. The mistakes in the initial solution also occur when S2 needs to be corrected in interpreting the percent subtraction operator. The following is a description of the data on the structure of thinking mistakes in the form of cognitive mapping based on Polya's theory.

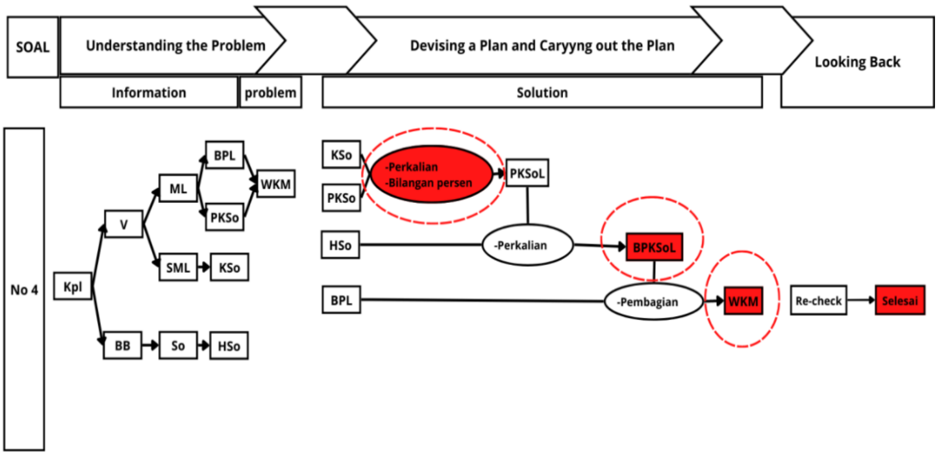


Figure 8. The cognitive mapping analysis of s2 mistakes in test number 4

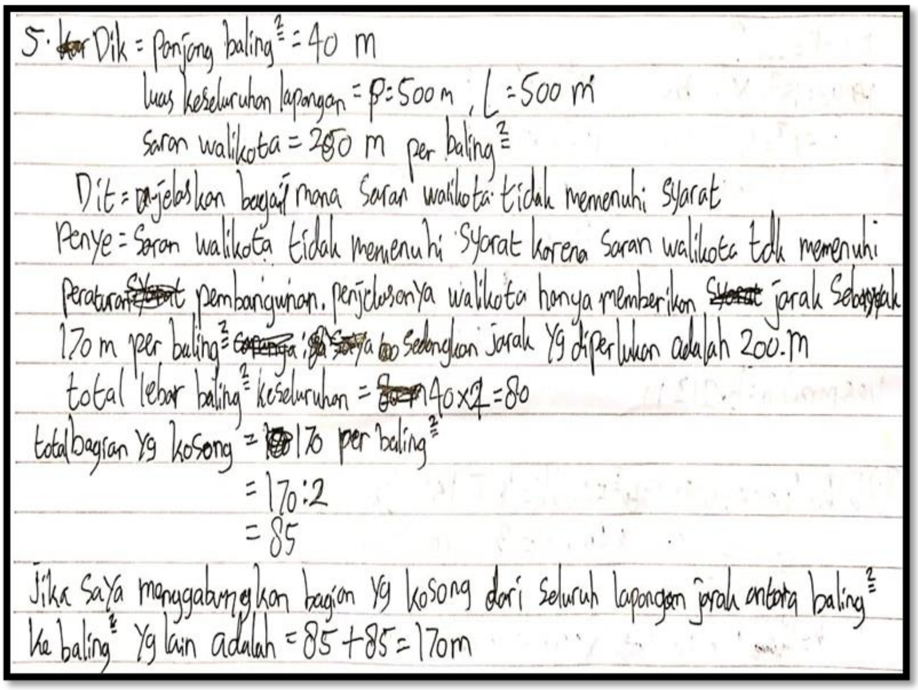


Figure 9. The s2 mistakes in test number 5

Based on the written answers above, it can be seen that S2 writes down what is known and asked in the question using understandable language. However, S2 wrote down some information from the questions, and some things needed to be corrected in the sentences describing the meaning of the questions. Furthermore, the interview process also showed S2 mistakes in understanding the information from the questions.

The following interview describes S2's thinking mistake in solving the question.

P : What do you know from question no 5?

S1 : As far as I know, the length of the propeller is 40 meters, the total length of the field is 500, the width is 500, and the distance of the construction rules is 5 x the distance of the propeller. Continue to advise the Mayor about the distance of the tower construction, which is 250 meters per propeller.

From the interview above, it can be seen that S2 needed to fully understand the information from the questions. S2 only captures one of the distance information suggested by the Mayor, which is 250 meters, even though only some of the recommended tower distances have an intermediate distance of 250 meters. S2 only sees what has been presented in the picture and ignores other important things in the picture of the question. From the quote above, it can be seen that S2 misunderstood the information. The next mistake occurred when S2 made a problem-solving plan.

The following is an interview that describes S2's thinking mistakes in preparing a problem-solving plan.

P : How did you solve the problem?

S1 : First, we know that the minimum distance for the construction rules is 5 x the length of the propeller, which means 200 meters. Then the total width of the propeller of one tower is 80 meters.

P : 80 meters from where?

S1 : the overall length of the propeller of one tower (2 x 40 meters)

P : Okay, keep going!

S2 : The total distance of the empty intermediate is 170 meters

P : You mean 170 meters?

S2 : (explaining while illustrating the meaning) The total distance between the two towers is 250 meters. One tower's propellers' width is 80 meters, so the remaining distance is 170 meters.

P : What's the next step?

S2 : The total space is 170 meters. I divide it in half because there are two towers. If I combine the space of the entire field, the distance between the propellers to the other propellers is 85 + 85 = 170 meters. Because 170 meters < 200 meters, the Mayor's suggestion needs to meet the minimum regulations.

P : try to re-explain and describe/illustrate the meaning of the regulation on paper.

P : (Drawing while explaining) The distance between the two power plant towers is 200 meters. So, for example, this is tower one, the length of the propeller is 40 meters, then this is the second tower, the length of the propeller is 40 meters, now the distance from here to here should be 200 meters.

From the quote above, the misunderstanding of the information is increasingly clear from the intended solution. For example, S2 considers that the minimum distance rule of 200 meters is the shortest distance between 2 tower propellers, even though the problem is the minimum distance between two towers. This mistake occurred because of the need for S2's literacy skills to read questions rather than focus on discussing the questions. This misinformation has a big impact on the next steps to take.

Based on the analysis of Polya's problem-solving theory, it can be concluded that S2 needed to understand the problem's information due to the lack of S2's literacy ability in reading story questions. The second cause occurred because it only focused on seeing what was presented and ignored other important things in the picture question. The following is a description of the data on the structure of thinking mistakes in the form of cognitive mapping based on Polya's theory.

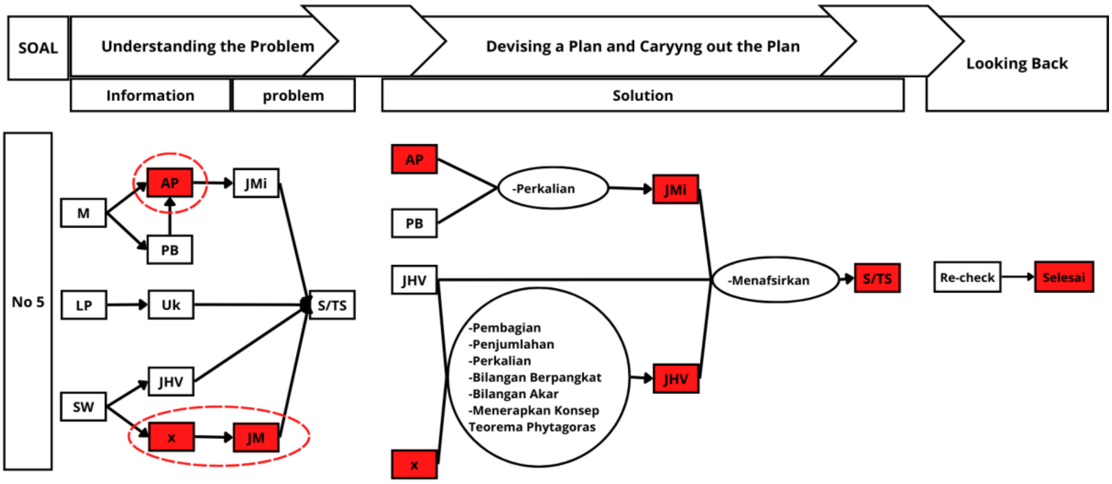


Figure 10. The cognitive mapping analysis of s2 mistakes in test number 5

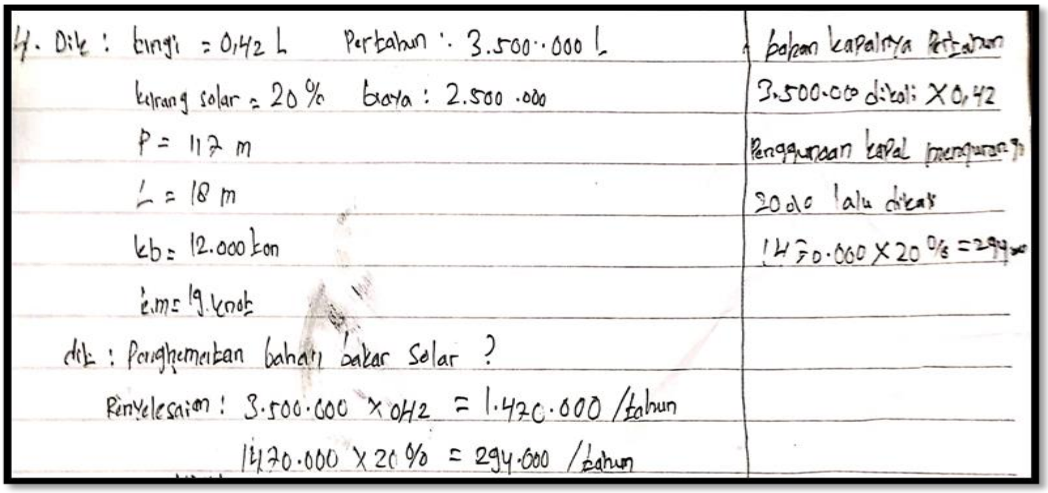


Figure 11. The mistake of s3 in test number 4

Based on the written answers above, S3 wrote down some of the information provided by the questions using the language understood by S3. In the S3 question section, the question sentence needs to be completed, and the meaning of the written question sentence is different from the meaning intended by the question. In the completion section, the solutions only reached the written questions stage. So the next step is not continued. The following interview describes the structural mistakes of S3 thinking in solving test Number 4.

P : Okay then, what does the question ask the problem?
S3 : saving on diesel fuel, bro.
P : What do you mean?
S3 : How much does it cost to save kite fuel in one year, bro?

From the interviews conducted, S3 was able to explain the information from the questions. However, when asked to indicate the mistake from the question, the interview above shows that the mistake understood by S3 needs to be corrected. What S3 understands from the question is the cost savings generated after using a kite sail in one year, even though the problem faced by a further problem then that is showing the calculation of the time to save fuel for the kite sail so that it covers the cost of installing the kite screen. What is done at the completion stage shows the solution to the problem that S3 understands. However, it still needs to answer the true meaning of question number 4.

Based on the analysis of Polya's problem-solving theory, it can be concluded that S3 experienced a mistake in understanding what was asked about the cause because of the need for literacy skills for S2 in reading the meaning of the question. The following is a description of the data on the structure of thinking mistakes in the form of cognitive mapping based on Polya's theory.

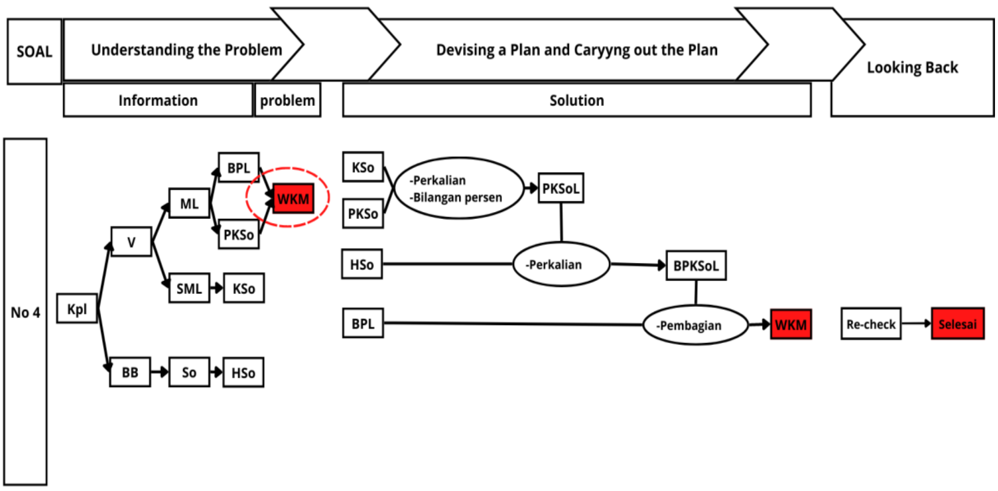


Figure 12. The cognitive mapping analysis of s3 mistakes in test number 4

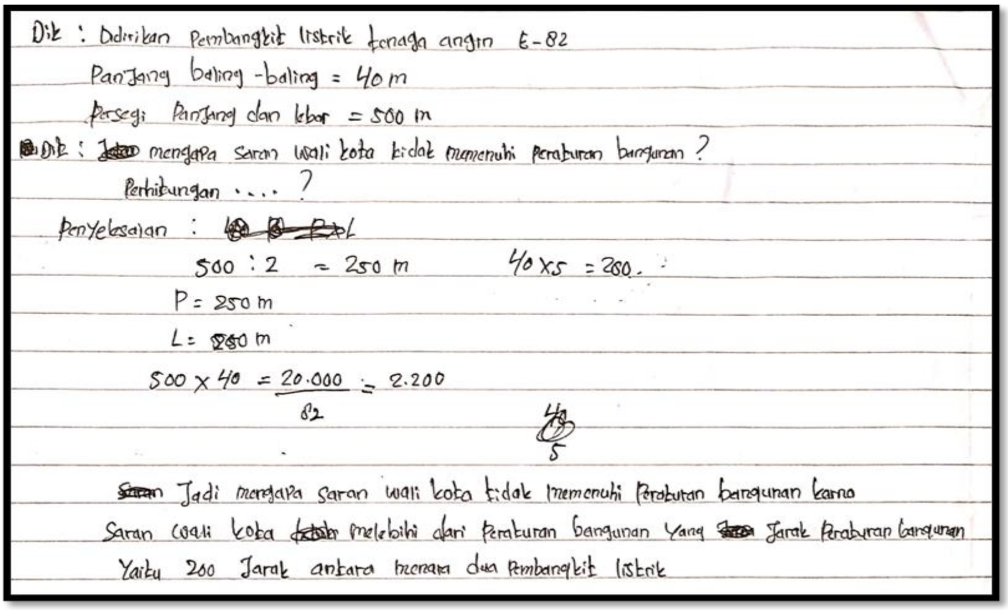


Figure 13. The mistake of s3 in question number 5

Based on the written answers above, it can be seen that S3 wrote several sentences of information from the questions, but some sentences needed to be written. In the completion section, several series of operations build a conclusion. But unfortunately, the resulting answer needs to be corrected. The following is the interview which shows the S3 mistake in completing question number 5.

P : From question number 5, what do you know?
S3 : Zedtown has decided to build several power generation towers...(reading the problem)
P : Can you not, because it was not read? Just tell me what information was captured from the question.
S3 : So Zed City will build a power plant tower. The length of the propeller is 40 meters. According to the building regulations, the minimum distance between the power generation towers is five times the length of the propeller. The Mayor suggested the construction as in this picture. So the question is, we are asked to show why the Mayor's suggestion does not meet the requirements.
P : Please explain the solution made.
S3 : (silence looks confused)
P : I mean, like this, where is this 500 from? Why do you divide it by 2?
S3 : Me, claw this, sis...
P : Why can you conclude that the Mayor's suggestion does not meet the suggestion?
S3 : Because of this, Sis, the distance recommended by the Mayor exceeds the building regulations, which is 200 meters.
P : What is the distance recommended by the Mayor?
S3 : 250 sis/bro.

From the dialogue above, it can be seen that S3 did not understand well the information from the question, S3 misunderstood the picture in the question, S3 concluded that the Mayor suggests that the construction between the two towers is 250 meters apart, even though there are several intermediaries between the two towers, which are more than short under 250 meters. Furthermore, S3 experienced a mistake in understanding the building rules. Although at the beginning of S3, it was stated that the minimum building distance rule between 2 power plant towers was five times the length of the propellers (5 x 40 meters = 200 meters), at the completion stage, a statement was found that contradicted the statement previously mentioned. S3 does not allow the construction of 2 towers at a distance of 250 meters. According to S3, the construction between the towers is 250 meters beyond the established rules. The statement clearly shows that S3 needed to understand the information correctly.

Based on the analysis of Polya's problem-solving theory, it can be concluded that S3 experienced a mistake in understanding the information about the problem due to a lack of S3 literacy skills in reading questions. First, students need to be able to focus on the intent of the story. The second cause occurs because they only focus on what has been presented in the picture and ignore other important things in the question image. The following is a description of the data on the structure of thinking mistakes in the form of cognitive mapping based on Polya's theory.

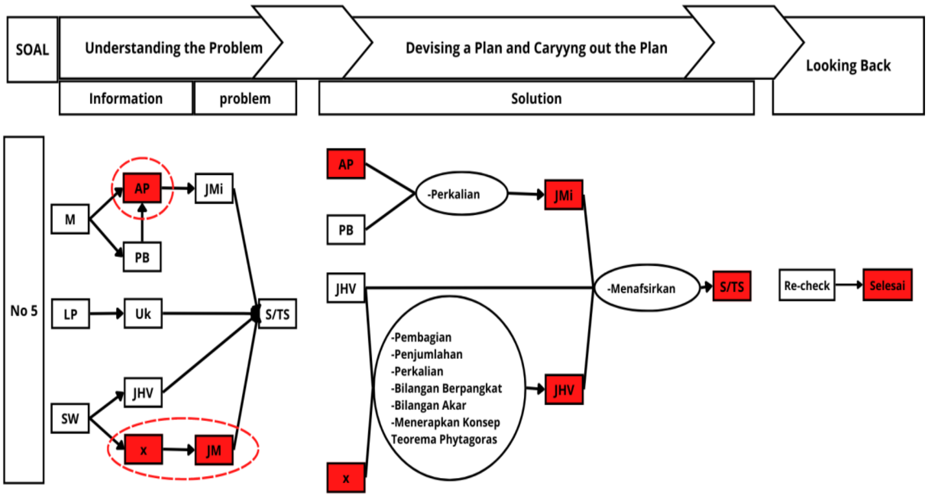


Figure 14. The cognitive mapping analysis of s3 mistakes in test number 5

The analysis results of the S2's thinking structure mistake in completing questions number 4 and 5

Based on the results of the written answer descriptions and S1, S2, and S3 interviews, it can be concluded that the types of mistakes are based on the thinking structure of S1, S2, and S3 in completing the PISA math test. For more details, please refer to the following table:

Table 1. The analysis of results of s1, s2, and s3 thinking structure mistakes in completing number 4

The Data Analysis of Mistake			
Understanding the Problem	**Devising a Plan**	**Carrying Out the Plan**	**Looking Back**
S1 and S2 did not have the mistakes, while S3 had mistakes in understanding what the questions asked because of S2's lack of literacy in reading the questions' meaning.	S1 and S2 need to correct compiling completion procedures due to a lack of reasoning of mathematical concepts. At the same time, S3 has a structured mistake.	S1 and S3 have structured mistakes. At the same time, S2 has a mistake in using the percent subtraction operator because they need to understand the concept of subtracting percent numbers well.	S1, S2, and S3 have structured mistakes.

Table 2. The analysis of results of S1, S2, and S3 Thinking Structure Mistakes in completing number 5

Error Data Analysis			
Understanding the Problem	**Devising a Plan**	**Carrying Out the Plan**	**Looking Back**
S1, S2, and S3 misunderstand information due to a lack of literacy skills in reading questions. The second cause of misinformation is ignoring other important things in the question.	S1, S2, and S3 have structured mistakes.	S1, S2, and S3 have structured mistakes.	S1, S2, and S3 have structured mistakes.

The Description of Students' Thinking Structure Mistakes in Completing PISA Math Question. Based on the analysis of the study results that have been done, it is known that most of the students still need help in the problem-solving process of PISA math questions. The mistakes in the thinking structure of problem-solving students in completing PISA questions according to Polya's theory analysis include, among others, students misunderstanding the problem, students needing to be corrected in devising a plan, carrying out the plan, and looking back. This finding is reinforced by research stating that students with low problem-solving abilities in completing PISA questions will experience mistakes in the completion step (Anggraini, Kusmayadi, and Pramudya 2018).

The thinking structure mistakes in understanding the problem are divided into two categories: the mistake in understanding information about questions and the mistakes in understanding questions. This mistake occurs in all subjects. For example, in question number 1, the mistake at this step was experienced by S3 as a mistake in understanding the information about the question because it only focused on seeing what the questions had presented. States that it is the same that students focus on one question information only so that they forget the information in the questions that must also be answered or developed. This can happen because they need to record the complete and comprehensive data on information about the questions (Andriani, Triyanto, and Nurhasanah 2021; Anggraini et al. 2018).

The mistakes in understanding information also occurred in question number 4. S3 also needed to improve in understanding what was asked due to a lack of literacy skills in reading the sentence's meaning of the question. The statement supports this statement that students' carelessness in making mistakes in understanding the information known from the questions can be caused by limited students' reading comprehension skills (Corporan, Martín, and García 2021). The mistakes in understanding this step also occur in question number 5 experienced by all subjects, like misunderstanding information caused by a lack of literacy skills in reading questions (Wuryantoro 2020). The second cause of misinformation because it ignores other clues in the question. Mistakes in understanding this problem can occur because students have yet to know the essence of the story question. After all, they only see what is available in the question and ignore other important things in the question yet.

The thinking structure needs to be corrected in devising a plan. This mistake occurs in all subjects and is the most common mistake. In question number 3, the mistake in this step is experienced by S3 as the mistake in determining the completion procedure because understanding the prerequisite material concepts of time, distance, and speed was still lacking. Utami also stated a similar thing in her research results that students' ability to arrange problem-solving plans can be seen through formula understanding or material concepts (Utami and Wutsqa 2017). In question number 4, the mistake in this step was experienced by S1 and S2 in determining completion procedures due to a lack of mathematical concept reasoning. This condition has also been found that low mathematical reasoning abilities cause students to have difficulty devising a plan (Pradana and Murtiyasa 2020). This mistake shows that PISA questions require the ability to apply concepts and how the concepts can be applied in various situations (Kurniati, Harimukti, and Jamil 2016). The mistake in devising the completion plan can also occur due to misunderstanding the problem. In the research conducted, the mistake was categorized as a structured mistake, namely a mistake triggered by the mistake that existed in the previous step.

The thinking structure in carrying out the plan occurs in all subjects. In question number 1, the mistake at this step was experienced by S3 in the form of a mistake in the process of interpreting the diagram data. The cause of this mistake is that the prerequisite material for the concept of pie chart data presentation must be mastered. In question number 3, the mistake in this step was experienced by S3 as the mistake in using the time formula for speed due to a lack of understanding of the material concepts of time, distance, and speed. In question number 4, the mistake at this step was experienced by S2 in the form of the mistake in using the percent reduction operator. The cause is that they need to master subtracting percent numbers better. The mistake in devising the plan also mostly occurs due to structured mistakes, namely the mistakes that are triggered due to the mistakes in the previous step (Corporan et al. 2021). The mistake in thinking structure in carrying out the plan occurs in all subjects (Fleurence et al. 2020). The failure to re-examine the mistake is correctly due to structured mistakes that existed in the previous step, either the mistakes at the step of understanding the problem or devising a plan) or carrying out the plan (Feng, Zhou, and Dong 2021).

Based on the description above, the subjects in this study each have an incomplete thinking structure mistake. The inability of students to solve problems correctly in completing PISA math questions is strongly influenced by the lack of literacy skills in reading the meaning of the questions, not focusing on important instructions on questions, mastery of understanding the concept of prerequisite material, lack of reasoning of mathematical concepts, mistakes in the interpreting process, mistakes in carrying out operations, and structured mistakes.

Defragmenting students' thinking structure through cognitive mapping based on Polya theory on PISA math questions. Problem-solving becomes a part of human thinking process activities. This process links various cognitive parts and other knowledge with one another. These parts are related to each other to make the framework of thinking structure in solving problems. The thinking structure of problem-solving is the framework of cognitive structures carried out during the problem-solving process (Wang et al. 2021). The difficulties or mistakes experienced by the students in solving problems can indicate that there are parts of the problematic-cognitive structure, either because they are disorganized, disconnected, or experiencing cognitive mistakes (Green and Zwiebel 2018).

Based on the analysis of the written answer sheets and the interview results on the PISA math questions, various student mistakes were found in completing the questions. These mistakes can indicate that in completing PISA math questions, the thinking structure experienced by the students is still not well organized, or in other conditions, there are still cognitive parts that are not interconnected yet (Wang et al. 2021). The students' thinking structure mistakes cannot be allowed because it will be a problem in the development of student learning. The mistake of thinking structure needs attention so that it does not develop in knitting the next mistake of thinking structure (Kristanto and Yunianta 2021).

They combine several references to the cognitive restructuring theory from several experts. The defragmenting interventions used include scaffolding-review, scaffolding-restructuring, scaffolding-explaining, conflict cognitive, and dis-equilibration, which is adjusted to the types and causes of mistakes experienced by the students based on the analysis of cognitive mapping for each question (Di 2021). After the subject received the defragmenting intervention, the subject's thinking structure was reworked by adding new patterns to connect them into a whole framework pattern of thinking structure (Kiger et al. 2021).

Based on defragmenting interviews conducted to overcome students' thinking structure mistakes in completing PISA math questions. The scaffolding review carried out in this study was an intervention in the form of directions for re-presenting work (de Jesús Cázares Balderas, Páez, and Martínez 2020). Including asking the subject to reread information questions, refocusing attention on the information, and directions for checking the re-writing of numbers and units in the completion made (de Jesús Cázares Balderas et al. 2020). In addition, they reviewed one of the words in the question sentence containing incorrect information or a reminder to check and re-correct changes in work understanding (de Jesús Cázares Balderas et al. 2020).

Scaffolding restructuring in this study is to rebuild understanding with interventions in the form of questions or directions that lead the subject to obtain the right understanding (de Jesús Cázares Balderas et al. 2020). Including giving questions or guiding to develop and find information about questions that are presented or not presented in the questions. The questions or directions lead to finding plans, the questions or directions lead to finding the right formula or concept, and the questions lead to completing the right completion plan.

Scaffolding explained in this study is an intervention through explanations or instructions to guide the subject to obtain the right understanding. Including the postulate explanation about the number of angle degrees in a flat triangle Euclidean geometry. The explanations of concepts and techniques for presenting data in pie charts, the brief explanations of the Pythagorean theorem rules, the root number operation, and the technical explanation of division containing decimal numbers. The dis-equilibration in this study is the questions that show a suspicious attitude of understanding to create thinking gaps so that students reflect on their answers (de Jesús Cázares Balderas et al. 2020). Including giving questions that show a suspicious understanding of incorrect reading information (Yang 2017). The questions show the researcher's doubts about interpreting other information sentences from incorrect questions. The repeated questions show the doubting attitude toward understanding, and the questions show the suspicious attitude to the steps made.

The conflict cognitive carried out in this study is providing examples that can create knowledge conflict so that students will finally think again about the answer, including giving examples of similar information sentences examples to deny the mistakes in understanding other information from wrong questions, giving examples of similar cases to deny the mistaken understanding of thinking in devising the completion plan, giving examples that can deny the formula misunderstanding, giving examples to deny the understanding about the mistaken plan completion process.

From the defragmenting intervention, there was a tendency for students with low mistake rates to require the least defragmenting intervention. In the treatment given, the students with low mistake rates only needed scaffolding review, scaffolding-restructuring, and dis-equilibration interventions and have yet to receive scaffolding-explaining and conflict cognitive interventions. Likewise, despite receiving all forms of defragmenting intervention, the students with moderate mistake rates rarely received scaffolding-explaining interventions. Most thinking structures are well-organized and do not experience many fatal cognitive problems, especially knowledge of prerequisite material concepts.

Meanwhile, the students with a high mistake rate require the most defragmenting intervention. In the given treatment, the students in this category require all forms of defragmenting intervention and are more likely to require scaffolding-explaining interventions. This is because most thinking structure is fragmented, and there are not many fatal cognitive problems due to the lack of knowledge and skills to understand prerequisite material concepts.

▪ CONCLUSION

Based on the problem statement, the objectives and results of the study were previously described based on appropriate and related theories. The students' thinking structure mistakes in problem-solving to complete the PISA questions were experienced by all subjects. Among others, students needed to understand the problem and be corrected in devising a plan, carrying out the plan, and looking back. The students' mistakes in solving problems of the PISA math questions are strongly influenced by several reasons, including the lack of literacy skills in reading the meaning of the questions, not focusing on important instructions on the questions, mastery of understanding the prerequisite material concepts, lack of reasoning of mathematical concepts, the mistakes in the interpreting process, the mistakes in performing operations, and structured mistakes.

Students who do not have serious cognitive pitting problems need less defragmenting intervention and rarely need scaffolding-explaining intervention. Meanwhile, students who experience serious cognitive problems require the most defragmenting interventions and tend to require scaffolding-explaining interventions more often.

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