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Computational Thinking Process of Prospective Mathematics Teachers in Solving PISA Model Problems

INTRODUCTION

Computational thinking is one of the essential abilities in education included in the curriculum, starting from primary, secondary, and further education (Qualls & Sherrell, 2010). CT is included in one of the abilities students must have in addition to reading, writing, and arithmetic. In Wing (2006) explained that computational thinking involves problem-solving, system design, and system understanding. Concerning problem-solving, CT is a technique to develop a solution. In ISTE (2015) explained that CT is one of the general abilities in developing creativity. In creativity, there is a creative thinking process in which one of the stages is understanding the information and problems provided (Sitorus, 2016). In the research, Kalelioglu et al. (2016) define processes in computational thinking consisting of problem identification, data representation, designing solutions, implementation of solutions, and evaluation and follow-up. Concerning problem identification, cognitive activity includes identifying information, understanding the main problem, and focusing on the problem. In line with Kallia et al. (2021), who explain the combination of mathematics and computational thinking, solving mathematics can be expanded again through computational thinking by focusing on problem formulation and solutions. This shows the role of problem orientation in computational thinking in order to develop solutions to a problem.

Computational thinking is only sometimes related to computer use. In today's era of 21st-century digitalization, an educator must be equipped with computational skills so that they can be implemented in real terms by students at both primary and secondary education levels. In Selby and Woollard (2013) explain computational thinking as a cognitive activity focused on work and not limited to problem-solving. The stages of computational thinking in the explanation consist of the ability to abstract, detail, algorithmic thinking, evaluation, and generalization. In Denning (2009) explains the notion of computational thinking as a systematic or algorithmic thought to obtain results based on initial conditions owned. This is in contrast to the understanding conveyed by Wing (2006) that a process consists of solving problems and designing systems using computer science. According to Cuny et al. (2010), computational thinking is needed to formulate problems and solve ideas. In the study, Aminah et al. (2022) defined the computational thinking process in solving mathematical problems consisting of abstraction, algorithmic, decomposition, and evaluation. Abstraction thinking has the notion of the ability to explain mathematical problems through models or images (Kallia et al., 2021; Wing, 2010). Algorithmic thinking is a detailed completion process written in detail at each step (Yadaf et al., 2014). The term used is step by step; Decomposition has the notion of the ability to cut complex problems into several small parts to be solved in order (Sute et al. (2017); and evaluation is defined as the process of validating problem-solving solutions (Repenning et al., 2017). According to Harnett (2015), computational thinking is an alternative to developing students' numeracy skills, one of which is by giving PISA model questions.

Context, content, and competency level are characteristics of PISA model problems (Ahyan et al., 2014; Jailani et al., 2020; OECD, 2018). Understanding context is a given problem related to everyday life, for example, social life and community work. The content includes Shape and Space, Change and Relationship, Quantity and Uncertainty. Competencies that can be developed include the ability to identify, plan, implement, and develop ideas in the problem-solving space. One interesting content to research is Change and Relationship. According to Jurnaidi and Zulkardi (2014), Change and Relationship content is proven to have a positive impact on students' reasoning skills and can connect between answers in writing. In addition, research conducted by Zulkardi and Kohar (2018) explained that giving PISA-based questions can improve students' basic abilities in mathematical calculations. This relates to the essence of students' computational problem-solving ability.

The research of Aminah et al. (2022) defines the computational thinking process of prospective mathematics teachers in solving Diophantine linear equation problems consisting of reflective abstraction thinking, algorithmic thinking, decomposition, and evaluation. The difference between this research and previous research lies in reflective abstraction thinking. Building new knowledge from concrete to abstract thinking is called reflective abstraction. This process requires a high level of thinking. In Kallia et al. (2021) explain two different findings related to computational thinking in mathematics education: the characteristics of computational thinking and essential aspects of computational thinking. His findings explain three critical aspects of computational thinking: problem-solving, cognitive processes, and transposition. Researchers assume that the process of thinking in problem-solving has similar characteristics to mathematical and computational thinking. Students' mistakes in solving PISA problems are the main factor in obtaining low Indonesian PISA assessment scores. Computational thinking ability is an important aspect of solving problems with the measurement character of PISA questions. Therefore, it is important to conduct this research to determine students' computational thinking processes in solving PISA model problems.

▪ METHOD

Research Design

In this study, qualitative methods were used to describe the computational thinking process of students in solving PISA model problems. Jenis penelitian kualitatif dengan pendekatan deskriptif bertujuan menggali dan menjelaskan suatu situasi atau masalah terkini serta mengkaji temuan penelitian (Arikunto, 2019). Students who take Basic Mathematics courses in the Mathematics Education Study Program, Universitas Muhammadiyah Purwokerto as research participants.

Research Subject

The number of participants involved was 32 people. Based on the results of previous tests, participants were grouped into low, medium, and high-ability categories. Each group was taken by one student by purposive sampling as an informant (Sukestiyarno, 2020). D1, D2, and D3 symbolize high, medium, and low-category informants. This technique is based on specific considerations, including good oral communication skills, academic grades, and polite behavior. These criteria support researchers in exploring students' computational thinking processes in solving PISA model problems.

Research Instrument

Two main instruments were used in data collection: computational thinking skills tests and interviews. The test questions are prepared to adopt the PISA problem model that meets context, content, and competence aspects. For the interview activity, the main focus is the computational thinking process, and researchers transfer in-depth information about the stages of computational thinking in solving PISA model problems. Experts first correct and validate the instruments used in collecting research data. The results showed that computational thinking skills tests and interview guidelines met valid and realistic aspects. Figure 1 below shows the computational thinking test instrument used in the study.

> City A has a square-shaped city park with a size of 100×100 m. To beautify the city park, the regent intends to plant ornamental grass throughout its parts, but there are two circular ponds of different sizes in the city park. The first larger pond is 10 m from the park's south side. The second smaller pool is 10 m from the park's north side. The distance between the first and second pools is also 10 m. The ratio of the diameter of the first pool to the second pool is 3:2. If it is known that the price of grass every 1 m^2 is IDR 50.000 and the budget owned is IDR 400.000.000, then how much is the remaining budget used?

Figure 1. PISA Model Computational Thinking Test Items

Data Analysis

After the data is collected, researchers conduct data analysis, including the data reduction stage, presenting data related to the main topic, and drawing conclusions (Sugiyono, 2015). At the reduction stage, data is selected according to the focus to be analyzed. Furthermore, the data is presented as tables and figures to clarify the research findings. The conclusion section explains findings about computational thinking processes based on test results and in-depth interviews with students. Before the test, it was conveyed that all activities in this study would not affect the assessment individually or in groups. Research results are used only for scientific works and purposes.

RESULT AND DISCUSSION

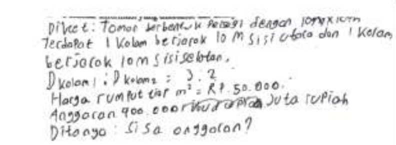
Table 1 describes the characteristics of the stages of the mathematical computational thinking process in solving PISA model problems. The stages of computational thinking consist of orientation, abstraction, decomposition, algorithms, and evaluation. The following is an explanation of each stage.

Table 1. Computational Thinking Process in Solving PISA Problems

No	Stage	Characteristics
1	Orientation	Understand the available information, write down the primary data and questions, explain the initial information related to the problem, and explain the initial resolution plan.
2	Abstraction	Identify information and problems in mathematical sentences, using mathematical notation or symbols to explain news or issues.
3	Decomposition	Write down the settlement in several interconnected sections, explaining the completion flow used.
4	Algorithm	Write answers systematically and in detail, using mathematical concepts correctly.
5	Evaluation	Recheck answers and write down simple conclusions.

Based on the test results, the following is presented as a description of the computational thinking process of students in solving mathematical problems of the PISA model. The report begins with students with high, medium, and low cognitive abilities. The focus of the description of computational thinking processes includes the stages of orientation, abstraction, decomposition, algorithms, and evaluation.

High Ability Student Category



Translation:
Given: The garden is square, 10m x 10m.
There is 1 pool 10m away on the north side and 1 pool 10m away on the south side.
$D_{pool\,1} : D_{pool\,2} = 3 : 2$
The price of grass per m^2 = IDR 50.000.
Budget IDR 400.000.000
Asked: What is the remaining budget?

Figure 1. D1 Response at the Orientation Stage

The orientation stage begins with looking at the problem and then identifying information that can be retrieved. The informant writes down known data and the context of the situation in question. Based on Figure 1, the informant wrote down the size of the garden, the comparison of two different ponds, and the core of the problem. This shows that the informant is focused on a given situation, in line with the results of the interview that illustrate the same thing as above.

R: Do you understand the given problem?
I: Yes, sir, I understand that the question is the remaining budget.
R: Have you written all the information?
I: Already, sir.
R: What plan did you use to solve the problem?
I: I will start by drawing the conditions according to the size and shape of the problem, and then I will try to connect the information that can be used.

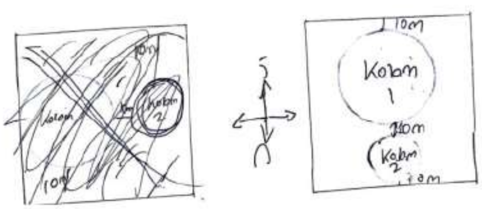


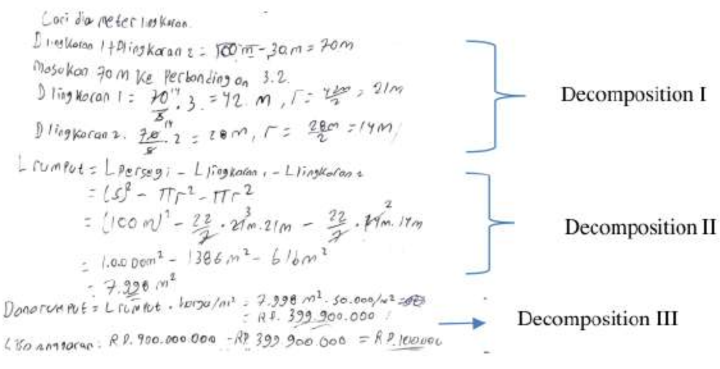
Figure 2. D1 Response at the Abstraction Stage

In solving problems, informants describe known information through pictures and mathematical symbols. As per Figure 2, the informant told two pools complete with their sizes, writing "Pool 1" and "Pool 2" on each circle. In addition, the mathematical symbols used to compare the two pools are $D_{pool\,1}$ dan $D_{pool\,2}$. According to the informant through interviews, this process is carried out to summarize a lot of information into shorter by the rules of mathematical writing. This is also commonly done by informants every time they solve mathematical problems. The following are the results of interviews with informants related to the abstraction stage.

R: What do you use to describe the entirety of the known information?
I: I pour in the form of pictures and mathematical symbols.
R: Can this process help you find a solution?
I: Yes, sir, this can help me find an initial solution. I can shorten that much information into another mathematical form.

R: Is this process normal or not?

I: Yes, sir, I usually do it when doing math problems, especially problems in the form of stories.



Translation:

Find the diameter of the circle.

$D_{circle\ 1} + D_{circle\ 2} = 100m - 30m = 70m$

Put 70m to a rasio 3:2

$D_{circle\ 1} = \frac{70}{5}.3 = 42m, r = \frac{42m}{2} = 21m$

$D_{circle\ 2} = \frac{70}{5}.2 = 28m, r = \frac{28m}{2} = 14m$

$L_{grass} = L_{square} - L_{circle\ 1} - L_{circle\ 2}$

$= s^2 - \pi r^2 - \pi r^2 = 100^2 - \frac{22}{7}.21.21 - \frac{22}{7}.14.14 = 10.000 - 1386 - 616 = 7.998m^2$

Grass fund = L_{grass} . price $1m^2$ = 7.998 – 50.000
= IDR 399.900.000

Remaining budget = IDR 400.000.000 – IDR 399.900.000 = IDR 100.000

Figure 3. D1 Response at the Decomposition Stage

The next stage is the decomposition of solving the problem. As seen in Figure 3, the informant divides the problem-solving into three: determining the circle's diameter, the grass area, and the remaining budget owned. These three parts become very important and sequential. In other words, to find the remaining budget, the three parts must be passed first. The interview results also support this explanation.

R: What did you do in resolving the above issue?

I: I determine the circle's diameter and then calculate the grass area. Finally, I figured out the remaining budget based on the size of the grass obtained.

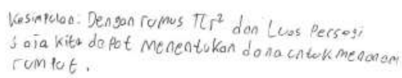
R: Are the sections sequential?

I: Yes, sir, to get the remaining nominal budget, all three must be done. Based on my answer like that, sir.

Figure 3 also shows the informant's systematic and precise answers. This is related to the algorithm stage. The informant used the formula of the diameter of a circle correctly, the area of a square, and the area of a process precisely and performed algebraic operations well and clearly. In addition, the informant wrote entirely and correctly on units of diameter, area, and rupiah notes. In the interview, the subjects explained the conceptual flow used in writing the solution.

R: What concepts are used in solving problems?

I: The diameter of a circle, the area of a square, the size of a process, and simple algebraic rules.
R: Try to explain again the completion flow you wrote.
I: At first, I used the circle diameter formula to determine the diameter of ponds 1 and 2, respectively, then used the square area and circle to find out the location of grass and used the multiplication rule to calculate the turf fund based on the grass area and grass fund per m2.
R: Is your answer detailed and precise?
I: Already, sir.



Translation:
Conclusion: With the formula πr^2 and square footage alone we can find the funds to plant grass.

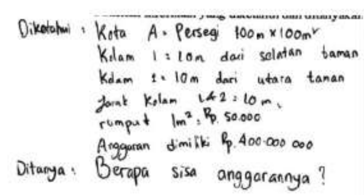
Figure 4. D1 Response at the Evaluation Stage

In the last stage, namely evaluation, the informant provides conclusions based on the final results. Based on Figure 4, the informant gave a decision in his language that is easy to understand, namely to determine the remaining funds simply using the rules of the circle and square formula. This conclusion is obtained by summarizing activities carried out in solving the problem. In addition, in interviews with informants, information was received that, before being collected, first corrected steps and final results. Here's an excerpt of the interview.
R: What can you conclude from that answer?
I: The conditions are enough to determine the remaining funds, namely the square and circle area concept.
R: Did you correct the entire answer?
I: Yes, sir, I re-corrected the steps and the suitability of the final result.

One of the characteristics of the PISA model problem is that it can develop students' ability to understand issues, design solutions, and generalize solving ideas. Computational thinking ability is a process of solving problems using mathematical logic that is carried out systematically, starting from orientation to the problem, designing solutions, applying, and writing in detail. The computational thinking process of students in solving PISA model problems consists of orientation, abstraction, decomposition, algorithm, and evaluation stages. A vital point distinguishing research findings from previous research is the orientation stage. Students understand the problem carefully and identify all the essential information used to generate solution ideas. In line with the study of Supiarmo et al. (2022) and Suntaryati et al. (2023), they explained that the PISA model problem can be implemented to improve computational thinking skills. Research The characteristics of the PISA model problem correlate with the core computational thinking process to solve mathematical problems. Computational thinking cannot be separated from the problem-solving space, so computational thinking is an inseparable series in the problem-solving process. About the PISA problem, Harangus (2018) explains that PISA measurement is not limited to the quality of education but can be used as a measurement of problem-solving, including computational thinking.

Students with high academic ability can demonstrate in writing the computational thinking process in solving PISA model problems starting from the orientation, abstraction, decomposition, algorithm, and evaluation stages. In the orientation stage, students can understand the situation well. This is evidenced by being able to write down all known information and the core of the problem. In the completion process, students write down the steps systematically, clearly, and correctly. This result aligns with research by Suntaryati et al. (2023), which revealed that students with high abilities meet the algorithm aspect, namely using mathematical rules correctly and solving steps written sequentially and in detail. In addition, at the evaluation stage, students write the conclusion in their language logically and check all the answers along with the completion steps.

Medium Ability Student Category



Translation:
Given: City A = square 100m x 100m
Pool 1 = 10m from the south of the park
Pool 2 = 10m from the north of the park
Distance between pools 1 & 2 = 10m
$1m^2$ grass = IDR 50.000
Budget owned = IDR 400.000.000
Asked: How much is the remaining budget?

Figure 5. D2 Response at the Orientation Stage

The caption in Figure 5 shows that the informant managed to write down all the known information and the core of the problem asked. In the information identification section, the informant wrote the area of city A, the location of each pool 1 and 2, and the amount of funds owned. At the core of the problem, the informant writes down the amount of the remaining budget held. When the informant was asked about the initial knowledge he remembered, he immediately answered the concept of square area, namely the length of the side multiplied by the side. The following is an excerpt from an interview with the informer.

R: Do you understand the given problem?
I: I understand, sir.
R: Try to explain it briefly.
I: I write down information ranging from the city's shape and area to the budget you have. According to my understanding, the main question is your remaining budget.
R: What do you first remember after looking at the problem?
I: I remembered the square area formula.

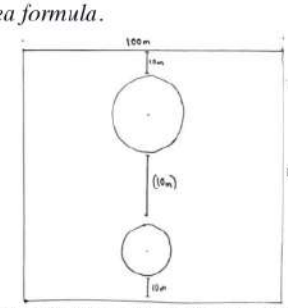


Figure 6. D2 Response at the Abstraction Stage

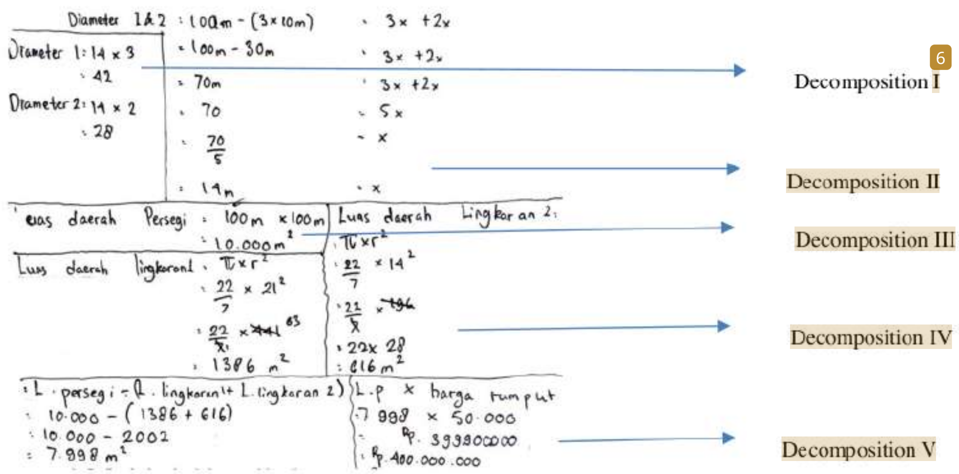
Figure 6 shows the cognitive activity of the informant at the abstraction stage. The informant translates the problem into a more mathematical visual form. Based on the information obtained, the informant can present it in pictures representing the entire information obtained. The informant made a box in which there were two different circles, the circles depicting several ponds. The distance between the two pools is marked with a line segment and honored with several 10 m. The figure shows the distance between the two pools. The interview results also explain information related to problem abstraction.

R: Do you use mathematical symbols or sentences to explain information?

I: Yes, sir, I use mathematical sentences such as "diameter 1, diameter 2, L. Square, and grass 1 m2. I use it to explain information to make it more concise and mathematical.

R: What do you do next to find a solution?

I: I present all the information in the form of pictures. This makes it easier for me not to read the questions repeatedly.



Translation:

Diameter 1 = 14x3=42, diamater 2 = 14x2 = 28

Diameter 1&2:

$100m - (3x10m) = 3x + 2x$

$100m - 30m = 3x + 2x$

$70m = 5x$

$\frac{70}{5} = x$

$14m = x$

Square area =100m x 100m = 10.000m^2.

Area of circle 1 = $\pi x r^2 = \frac{22}{7} x 21^2 = 1.386m^2$

Area of circle 2 = $\pi x r^2 = \frac{22}{7} x 14^2 = 616m^2$

Area = square area– area of circle 1 + area of circle 1

= 10.000-(1386+616)= 10.000-2002= 7.998m^2.

Area x price of grass = 7.998 x 50.000 = IDR 399.900.000= IDR 400.000.000

Figure 7. D2 Response at the Decomposition Stage

In solving the problem, the informant carried out the calculation in stages. As shown by Figure 7, the informant begins by calculating diameters 1 and 2, square area, and circle area 1 and 2, and finally calculates the remaining budget based on the site obtained. This proves that the informant divides problem-solving into several interrelated small parts. This stage also helps the informant's thinking in solving problems mathematically. The following is an excerpt from an interview with the subject.

R: Can you describe the troubleshooting flow?

I: In solving the problem, I divide the solution into parts and mark them in small boxes. I am starting by calculating the diameter area of each pool to calculate the remaining budget based on the size of the site.

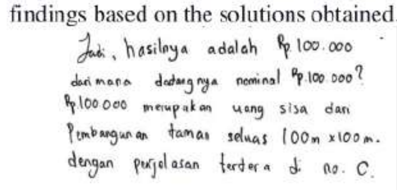
R: Are you used to it that way?

I: Yes, sir. If the problem is contextual and complex, it is easier to solve in that way and more convenient, sir.

The above small parts are solved correctly and in detail using precise mathematical rules in the calculation process. For example, in calculating the area of circles 1 and 2, the informant uses the formula correctly, and the calculation can be clearly understood. Likewise, the other parts are done in detail. In this case, the informant can reach the algorithm stage indicated by the calculation process carried out systematically, in fact, and correctly. The informant also explained the same thing regarding the algorithm stage when asked through the interview.

R: What are some mathematical rules or formulas used in solving problems?
I: The diameter rule of a circle, the area formula of a square, and a process, the power of simple algebra.
R: Are you familiar with the rules?
I: Yes, sir, I understand.
R: Do you think the answers written are detailed and precise?
I: Already, sir.

The informant's last stage is to re-examine the answers and provide conclusions. This stage is referred to as evaluation. Figure 8 describes the activities carried out by subjects in giving findings based on the solutions obtained.



Translation:
So, the result is IDR 100.000
Where did the nominal amount of IDR 100.000 come from?
Rp. 100,000 is the remaining money from constructing a 100m x 100m park with an explanation stated in number C.

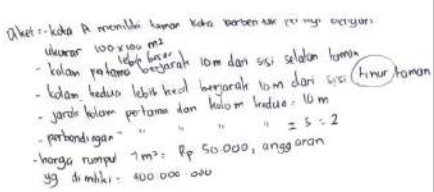
Figure 8. D2 Response at the Evaluation Stage

The informant gave a complete conclusion sentence starting from the results obtained to the area of the park built. The sentence naturally came from the Informant. In addition, the interview results also explore information related to informant activities in conducting re-examinations. Here are the results of the conversation in the interview.

R: What do you do when you're done working on the problem?
I: I corrected the answer and steps, sir.
R: Was an error found?
I: There is a sir. I miscalculated it, and then I corrected it.
R: Are you used to giving conclusions and recorrecting the results of the work?
I: I often like that, sir, especially the contextual problems.

Students in the high-ability category are the same, students with medium ability can answer PISA model problems correctly and clearly. The student's answer shows an excellent computational process, including orientation, abstraction, decomposition, algorithm, and evaluation stages. In explaining known information, students use mathematical symbols or notation to represent the information. Students also use visualization aids to describe the core questions to be answered. According to Gravemeijer (2011), abstraction thinking is an aspect that helps students translate abstract models into real contextual problems. To solve the problem, category students sort the answers into interrelated parts. Starting from the relatively easy beginning to the main question. The ability to decompose is not easy for students because the problem is complex. In line with Rich et al. (2018), decomposition is an essential aspect of problem-solving, and one's ability to separate issues into small parts to be solved is not easy because students understand decomposition techniques but need help applying the concept. Similar to high ability, students in the medium category at the evaluation stage can apply re-examination of answers and make a final statement as part of the conclusion. The evaluation stage is the last series of a problem-solving process where students obtain valid final results based on previous experience (Worthen et al., 2019).

Low Ability Student Category



Translation:
Given:

- City A has a square city park measuring 100 x 100m.
- The first larger pool is 10m from the south side of the park.
- The second smaller pool is 10m from the east side of the park.
- Distance between the first pool and the second pool = 10m.
- The ratio of the first pool to the second pool = 3:2.
- Price of 1 m^2 grass = IDR 50.000, budget = IDR 400.000.000

Figure 9. D3 Response at the Orientation Stage

Based on Figure 9, it is explained that the informant can write down all the information contained in the problem. The information in question is the size of city A and its size, the difference in the size of two pools, the comparison of the two pools, the price of grass, and the total budget owned. There is something different about the responder's answer: the absence of the main problem asked. However, when conducting the interview, the informant can explain the central question of the problem. In addition, the informant also admitted that he needed to be more thorough in identifying the given situation.

R: Are you able to understand the problem?
I: Yes, sir, I have looked at it.
R: What do you think is known?
I: The characteristics of city A, the size of two different ponds, the price of the lawn, and the budget you have now.
R: What is asked in the matter?
I: The remaining budget you have.
R: However, I see nothing in your writing. Try to explain.
I: Yes, sir, that's right, I didn't write down the core question because I wasn't careful.

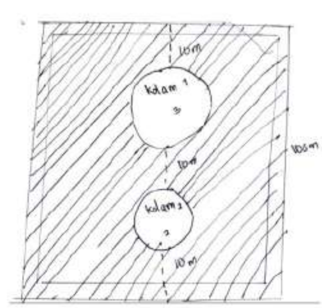
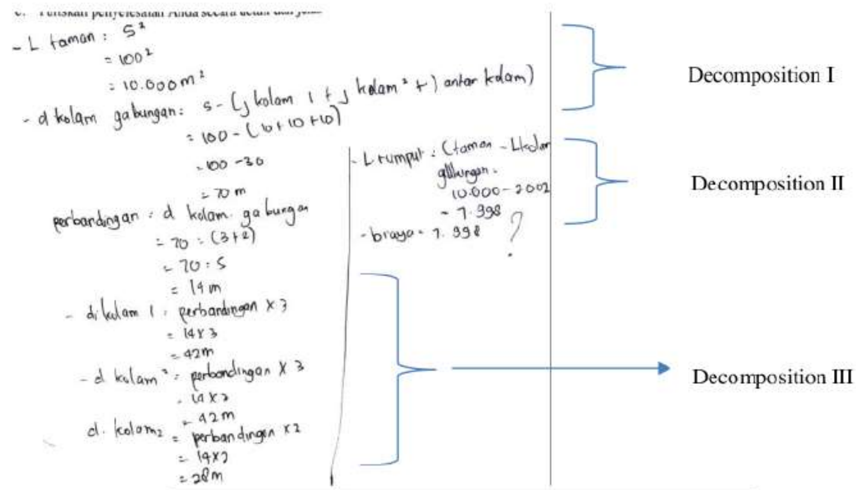


Figure 10. D3 Response at the Abstraction Stage

The informant's next step is to describe the entire information in a visualization. This stage is called abstraction. In Figure 10, the informant wrote the distance between Pools 1 and 2, the size of the city park, and the length of each pool to the park's edge. In addition, informants use mathematical symbols to explain the area and diameter of the collection. Example L_{taman} dan d_{kolam} each describe the garden's location and the diameter of the pond. The results of interviews with informants revealed that the use of notation helps in finding problem-solving and more effectively explains long mathematical sentences. The following are the results of the discussion in the abstraction stage.

R: In the process, do you use mathematical symbols?
I: That's right, sir. I use mathematical symbols to explain the area and diameter.
R: How do you find the solution?
I: I used the image to describe the condition of the problem. Because the problem is in the form of a story, it will be easier if presented in pictures. This helped me to find a solution.



Translation:

- Park area = $s^2 = 100^2 = 10.000m^2$
- *d* combined pools = *s* – (j pools 1 + j pools 2 + j between pools
  = 100- (10+10+10) = 100-30 = 70
- Comparison d of combined pool = 70: (3+2) = 70:5 = 14m
- *d* pools 1 = ratio x 3 = 14 x 3 = 42m
- *d* pools 2 = ratio x 2 = 14 x 2 = 28m
- *L* grass = park – combined area = 10.000-2002 = 7.998?

Figure 11. D3 Response at the Decomposition Stage

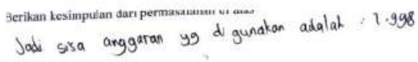
To simplify the resolution process, the informant breaks the problem into several parts that are sequential to each other. The first division is carried out to calculate the area of the overall garden and the distance between the pond and the garden. The second part compares the two pools and then calculates the distance between pool one and pool two, respectively. The last function calculates the remaining grass area and the costs required. The results of interviews with informants dug up information about the flow of completion carried out in order.

R: Describe what you did until you found the result.

I: To solve the problem, I divided it into three core parts. First, I started calculating the area of the garden owned. Second, I processed information about the comparison of distances between pools. Third, I figure the remaining budget based on the remaining area of the park.
R: Does it relieve you in the calculation?
I: Yes, sir.

Based on Figure 11, it is clearly illustrated that the Informant's answers are carried out in order and clearly. This section describes the algorithm's stages in solving the problem. The calculation process uses the correct rules, the units used are also suitable, and the final result of each part is also correct. However, in the last section, the Informant must complete the final result according to the main question. The Informant stopped at the remaining area of the park even though what was asked was the remaining budget based on the remaining area of the park. The interview with the Informant asks again the reason for not being resolved, and the Informant can also answer correctly.

R: Has your answer been written entirely according to the question?
I: It turns out that there is an incomplete part, sir. After my correction, I did not answer the question.
R: What are the drawbacks?
I: I calculate the remaining area of the garden multiplied by the cost of grass per m^2.



Translation:
So, the remaining budget used is 7.998.

Figure 12. D3 Response at the Evaluation Stage

Because of the lack of answers in the previous stage, it results in errors in giving conclusions. However, after the interview, the informant can provide the correct decision. As in Figure 12, the error arises due to the activity of the Informer in re-examining each step of completion until the final result is obtained. The following is an excerpt of the interview in the evaluation stage.

R: Did you check the whole answer?
I: Yes, sir, I finally know where he went wrong.
R: What errors have you found?
I: The calculation in the remaining part of the budget is based on the rest of the grass area.
R: What is the correct conclusion in your opinion?
I: After recalculation, the conclusion is that the remaining budget used is IDR 100,000.00.

The characteristics of the computational thinking process in students in the low ability category differ from the high and medium categories. The difference lies in the orientation stage and the algorithm. At the orientation stage, high-category students must complete writing down all information, including the subject asked in the question. This directly affects cognitive activity at the algorithm stage. The existing data cannot be correctly identified, so the completion steps can only be written partially and perfectly. Students who can understand the problem and write down all the essential information that can be used to solve the problem will easily find the correct solution (Hee et al., 2019). The research shows the potential position of orientation activities in problem-solving. With these conditions, it will have an impact on the algorithm stage. In this stage, the completion steps are written in detail and correctly, but low-category students need help to reach the algorithm stage fully. The cognitive knowledge of low-category students is the main obstacle. The knowledge possessed by students is limited, resulting in a lack of mathematical concepts used in solving. This is in line with de Lange (2003), who explained that in learning at school, the knowledge possessed by students can be used to generate solving ideas and apply them to problems. This is also supported by Stillman (2015), that someone who has good cognitive knowledge when given an issue, can understand and detail the problem correctly.

▪ CONCLUSION

Computational thinking is essential to the problem-solving process needed in today's digitalization era, especially in solving complex problems such as the PISA model. The computational thinking process of prospective mathematics teachers in solving PISA problems consists of five stages: orientation, abstraction, decomposition, algorithms, and evaluation. In the group of high and medium ability, students write cognitive activities clearly and in detail at each stage of orientation, abstraction, decomposition, algorithms, and evaluation. Students understand problems and essential information that can be used in solving problems, present issues in mathematical symbols and visualizations, divide into several parts of solving written in detail, provide conclusions according to the core questions, and re-examine the final results. Different from students in the low ability category, some things could still be improved in answers. For example, students need to write down what is asked in the problem or the process of solving from beginning to end in detail. This relates to the cognitive activity of students at the orientation and algorithm stages. Research is limited to mathematical problems of the PISA model. It is more interesting if the other issues presented are open-ended. This is associated with students' creative thinking ability in solving open-ended problems because, in the 21st century, prospective teachers must have creativity in solving mathematical problems. Further research can be studied on the computational thinking process of students in solving open-ended problems and the correlation between computational thinking and mathematical creative thinking.

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