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TRANSFORMATION OF THE COMPUTATIONAL THINKING PROCESS OF STUDENTS TO SOLVE MATHEMATICAL PROBLEMS THROUGH REFLECTION

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Abstrak
Berpikir komputasional dapat memudahkan siswa memecahkan masalah matematika, karena melibatkan berbagai keahlian dan teknik yang melatih siswa merumuskan masalah kompleks menjadi sederhana. Namun pendekatan pembelajaran saat ini membatasi siswa mengembangkan kemampuan berpikir komputasional. Guru cenderung tidak melakukan inovasi dan lebih dominan menggunakan pembelajaran monoton yang mengakibatkan kemampuan berpikir komputasional siswa menjadi rendah. Untuk merangsang terjadinya transformasi terhadap proses berpikir komputasional siswa dilakukan melalui refleksi. Penelitian ini bertujuan mendeskripsikan transformasi proses berpikir komputasional siswa pada pemecahan masalah matematika melalui refleksi. Jenis penelitian ini adalah penelitian deskriptif dengan pendekatan kualitatif. Data penelitian terdiri atas jawaban siswa, hasil think aloud, dan hasil wawancara semiterstruktur. Hasil penelitian menunjukkan bahwa siswa kemampuan pemecahan masalah rendah mengalami asimilasi pada tahap dekomposisi saja, sementara pada tahap pengenalan pola, abstraksi dan berpikir algoritma siswa mengalami akomodasi. Hal ini dikarenakan dalam menyusun strategi dan melaksanakan rencana siswa membutuhkan refleksi untuk mengenali pola, mengaplikasikan pola, membuat kesimpulan terhadap solusi penyelesaian, dan melengkapi algoritma yang belum lengkap. Adapun siswa yang memiliki kemampuan pemecahan masalah sedang mengalami asimilasi pada tahap dekomposisi dan pengenalan pola, sedangkan pada tahap abstraksi dan berpikir algoritma terjadi akomodasi. Hal ini disebabkan dalam melaksanakan rencana siswa membutuhkan refleksi untuk memperbaiki kesalahan penggunaan pola, membuat kesimpulan jawaban, dan melengkapi algoritma.

Kata kunci: Refleksi; Berpikir Komputasional; Pemecahan Masalah

Abstract
Computational thinking can make it easier for students to solve mathematical problems because it involves various skills and techniques that train students to formulate complex problems into simple ones. However, the current learning approach limits students from developing computational thinking skills. Teachers tend not to innovate and are more dominant in using monotonous learning which results in low computational thinking skills for students. Reflection is carried out to stimulate the transformation of students'

computational thinking processes. This study aims to describe the transformation of students' computational thinking processes in solving mathematical problems through reflection. This type of research is descriptive research with a qualitative approach. The research data consists of student answers, think-aloud results, and semi-structured interview results. The results showed that students with low problem-solving abilities experienced assimilation at the decomposition stage only, while at the pattern recognition, abstraction, and algorithmic thinking stages students experienced accommodation. This is because in formulating strategies and implementing plans students need reflection to recognize patterns, apply patterns, draw conclusions about solutions, and complete incomplete algorithms. Meanwhile, students who have moderate problem-solving abilities experience assimilation at the decomposition and pattern recognition stages, while at the abstraction and algorithmic thinking stages accommodation occurs. This is because in implementing plans students need reflection to correct errors in using patterns, draw conclusions, and complete algorithms.

Keywords: Reflection; Computational Thinking; Problem Solving

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INTRODUCTION

Computational thinking was first popularized by a computer scientist named Seymour Papert in 1980. Several developed countries have begun to introduce computational thinking at the elementary and junior high school levels (Angeli & Giannakos, 2020). This policy was implemented to train students from an early age in computational thinking and as a solution to the difficulties of teachers in innovating the monotonous learning approach that has been commonly used so far (Città et al., 2019). Computational thinking is a problem solving process that is carried out using logic by paying attention to the order in which it is done (Agbo et al., 2024).

Because computational thinking involves methods that teach students to simplify problems and foster their creativity, it can help students address a variety of challenges (Supiarmo, 2021b). However, students' capacity to acquire computational thinking abilities is actually constrained by the current teaching methodology. This is due to teachers' lack of creativity in the classroom and their frequent use of traditional teaching methods (Cahdriyana, 2020). Teachers are accustomed to employing formulas to help skill-oriented students grasp, after which they prioritize memorization. This approach therefore has a minimal effect on students' computational thinking abilities since it reduces their enthusiasm for learning these skills (Agbo et al., 2024).

The majority of pupils employed general techniques, according to the findings of the preliminary study conducted in two distinct classes, namely class XI MA Daruttauhid Malang and SMA Islam Sabilurrosyad. Following the assessment, pupils' computational thinking abilities were restricted to pattern recognition; they lacked the ability to think abstractly or algorithmically. This results from mistakes and insufficient, methodical steps in students' problem-solving processes. The conclusion that pupils' computational thinking abilities are still lacking is based on this finding. The findings of this preliminary investigation support earlier research that explains why students' average computational thinking skills remain in the low range and why their methods are less logical, allowing them to only advance to the pattern recognition stage. However, there are still relatively few students that think about algorithms and reach the abstraction level.

Through the description above, it is necessary to implement a treatment that can optimize students' computational thinking processes. It is expected that there will be a transformation of the computational thinking process from a low level (reaching decomposition and pattern recognition) to a high level (achieving abstraction and algorithms). Based on the literature study, there are several studies that present treatments to support students' computational thinking skills, including scaffolding in the form of directions, encouragement, and questions (Supiarmo et al, 2021). Furthermore, there are also those who implement quantum teaching and learning in interactive multimedia learning (Harsa Wara Prabawa, 2019), and through computer programming exercises, as well as unplugged activities (Brackmann et al., 2017). Then research Utami et al. (2024) implemented a project-based learning model. Kang et al. (2023) research developed a multidimensional computational thinking test for students based on. To stimulate the transformation of students' computational thinking processes, this research was carried out using reflection.

Reflection is defined as giving treatment with the aim of students being able to remember certain concepts in their minds in order to solve problems (Muhtadin, 2020; Supiarmo, 2021c). Reflection is given through feedback in the form of questions that stimulate students' cognitive abilities to check the problem-solving steps that have been completed. In addition, treatment can be done through giving work and certain questions to be answered independently, with the intention of training the accuracy of students' thinking skills. Then, reflection is an important solution in developing students' mental processes towards problem solving.

Reflection is a treatment that has been proven to systematically improve the mental structure of students. Reflection is also able to stimulate students to recall the knowledge previously obtained and then implement the solutions found (Muhtadin, 2020; Novita Ainurrohmah, 2016). In general, reflection provides good benefits, such as stimulating students to understand the problem thoroughly and formulating an appropriate plan to obtain accurate problem answers (Susanti, 2021).

Reflection is a method that engages students in analyzing their learning experiences, identifying errors or gaps in understanding, and constructing new knowledge based on feedback. In the context of enhancing computational thinking, reflection plays a critical role by encouraging students to recall relevant concepts, connect new information with existing cognitive schemas, and evaluate their solutions. Through the processes of assimilation and accommodation, reflection allows students to correct mistakes, fill in unstructured steps, and create more systematic solutions. As a result, reflection not only helps students improve their computational thinking skills but also drives profound cognitive transformation from basic pattern recognition to more complex abstraction and algorithmic thinking.

The purpose of reflection in this research is to encourage students to develop computational thinking skills, especially in solving mathematical problems. Therefore, this research has a great opportunity to be one of the best ways to help students improve their computational thinking skills. This is further strengthened by the absence of research on how students' mathematical problem solving is reflected in the transformation of computational thinking processes. So the problem formulation that will be answered in this research is "How is the transformation of students' computational thinking processes in solving mathematical problems through reflection?"

METHOD

This research method is descriptive with a qualitative approach. The subjects in this study were students in class XI MA Daruttauhid Malang and Islamic Senior High School Sabilurrosyad. Subject selection was done by the purposive sampling technique. The research data was obtained through worksheets, the results of think aloud exercises, and semi-structured interviews conducted with students. Subject selection was carried out by involving 98 students who had obtained mathematics material, namely linear programming. All students were given a linear programming test based on problem solving.

The research subjects were selected, namely four students, with the characteristics of two students with moderate abilities and two students with low abilities. Furthermore, to measure students' computational thinking skills, it is done using a test question instrument, which can be seen in more detail in Figure 1.

1. Dua media massa koran di Jakarta sedang membutuhkan orang untuk bekerja sebagai penjual koran. Iklan yang menunjukkan bagaimana kedua media massa membayar gaji penjual koran disajikan dalam Gambar 1 dan 2.

INDOPOS	KOMPAS
Dibutuhkan segera! Penjual koran dengan gaji: Rp.1.500,00 per koran, jika Anda mampu menjual sampai dengan 210 koran dalam satu minggu, ditambah Rp.10.000,00 per koran yang selebihnya terjual.	**Apakah anda mau dibayar tinggi dalam waktu singkat?** **Ayo!!!** Jual koran kami dan dapatkan Rp.500.000,00 per minggu, ditambah bonus Rp.300,00 per koran yang terjual.
Gambar 1. Iklan Indopos	**Gambar 2. Iklan Kompas**

Melihat kedua iklan tersebut, Budi tertarik dan memutuskan untuk melamar menjadi penjual koran. Oleh karena itu, ia perlu mempertimbangkan antara bekerja di Indopos atau Kompas. Buatlah grafik yang menggambarkan bagaimana pendapatan pekerja kedua media massa koran!

Figure 1. Test

Based on the computational thinking process indicators listed in Table 1, the outcomes of the work, think aloud, and subject semi-structured interviews were evaluated.

Table 1. Indicators of Students' Computational Thinking Processes

Problem Solving	Indicators of students' computational thinking	Sub- Indicators
understand the problem	Decomposition	Students can identify known and asked information from the given problem.
Strategy	pattern recognition	Students can recognize patterns in problems and build solutions.
Executing the plan	Abstraction	Students can draw conclusions about the problem-solving steps taken.
	Algorithms	Students can describe the steps of solving problems logically and systematically.
Looking back	-	-

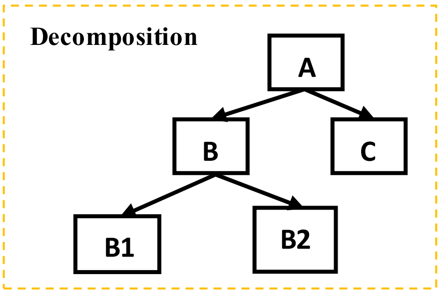
A student's proficiency with computational thinking processes is assessed using the findings of the examination of the three research data. so that it serves as the foundation for researchers to consider the unfulfilled phases of computational thinking. Furthermore, using Piaget's theory of thinking, research data from before and after reflection were examined to ascertain how students' computational thinking processes had changed. The three phases of this study's analytical methods are data reduction, methodical data presentation, and summarizing the key findings from the investigation.

RESULT AND DISCUSSION

This study aims to describe the transformation of students' computational thinking processes in solving mathematical problems through reflection. Four subjects were selected based on problem-solving ability: two subjects with low skills (S1 and S2) and two with moderate abilities (S3 and S4). The transformation was analyzed in four aspects of computational thinking: decomposition, pattern recognition, abstraction, and algorithmic thinking, by considering the cognitive mechanisms of assimilation and accommodation.

Transformation of Computational Thinking Process Subject S1

Data on the computational thinking process of S1 in solving mathematical problems before reflection can be seen in the following scheme:



Information:
- A: Problem
- B: Information known
- B1: Information known regarding Indopos
- B2: Information known regarding Kompas
- C: Information requested

Figure 2. S1 Computational Thinking Process in Solving Mathematical Problems Before Reflection

When given a linear programming problem-solving problem before reflection, S1 showed limited initial ability at the decomposition stage. He was able to identify known information, such as the type of work and the amount of income per hour from two companies, namely Indopos and Kompas. However, this understanding was only superficial. When asked to state it in the form of a function, S1 only copied the numbers from the problem without compiling the correct mathematical relationship. This shows that assimilation occurs only at the initial stage in S1's thinking process, but there has been no further cognitive process to the pattern recognition, abstraction, or algorithms stages.

After the reflection process was given, namely in the form of trigger questions such as: "Does the function you wrote to show the correct relationship between working hours and income?" or "What does the intersection point of the two graphs indicate?", S1 began to review his thinking process. This reflection was carried out in the form of guided discussions and written feedback. S1 was asked to correct and complete the graph and worker income function using more accurate and logical data.

The transformation began to be visible when S1 corrected the mathematical function that was initially wrong. He then wrote the Indopos income function as: $y = 20x + 100$ and Kompas as: $y = 25x$. S1 also describes the re-graph more accurately, by determining the intersection points and choosing the right scale on the x and y axes. This shows that he begins to recognize the pattern of the relationship between the variables of working hours and total income. So there is an indication that accommodation has occurred in S1's thinking process.

Next, at the abstraction stage, S1 wrote that the graph intersection point occurred at $x = 4$, and concluded that after 4 hours of work, Kompas workers' income was greater than Indopos. This is a form of simplification of previously scattered information, into one key conclusion. This proves that S1 has undergone a reconstruction of the thinking scheme, from just memorizing information to being able to reason.

In the final stage, S1's algorithms also showed significant improvement. After being given reflection, S1 compiled the steps starting from reading the question, forming a function, determining the intersection point, drawing a graph, to concluding: "If working hours are less than 4, Indopos is greater. If more than 4, Kompas is greater.". This compilation shows that S1 not only understands the concept but is also able to execute the solution logically and systematically. The computational thinking process of S1 in solving mathematical problems during reflection can be seen in Figure 3.

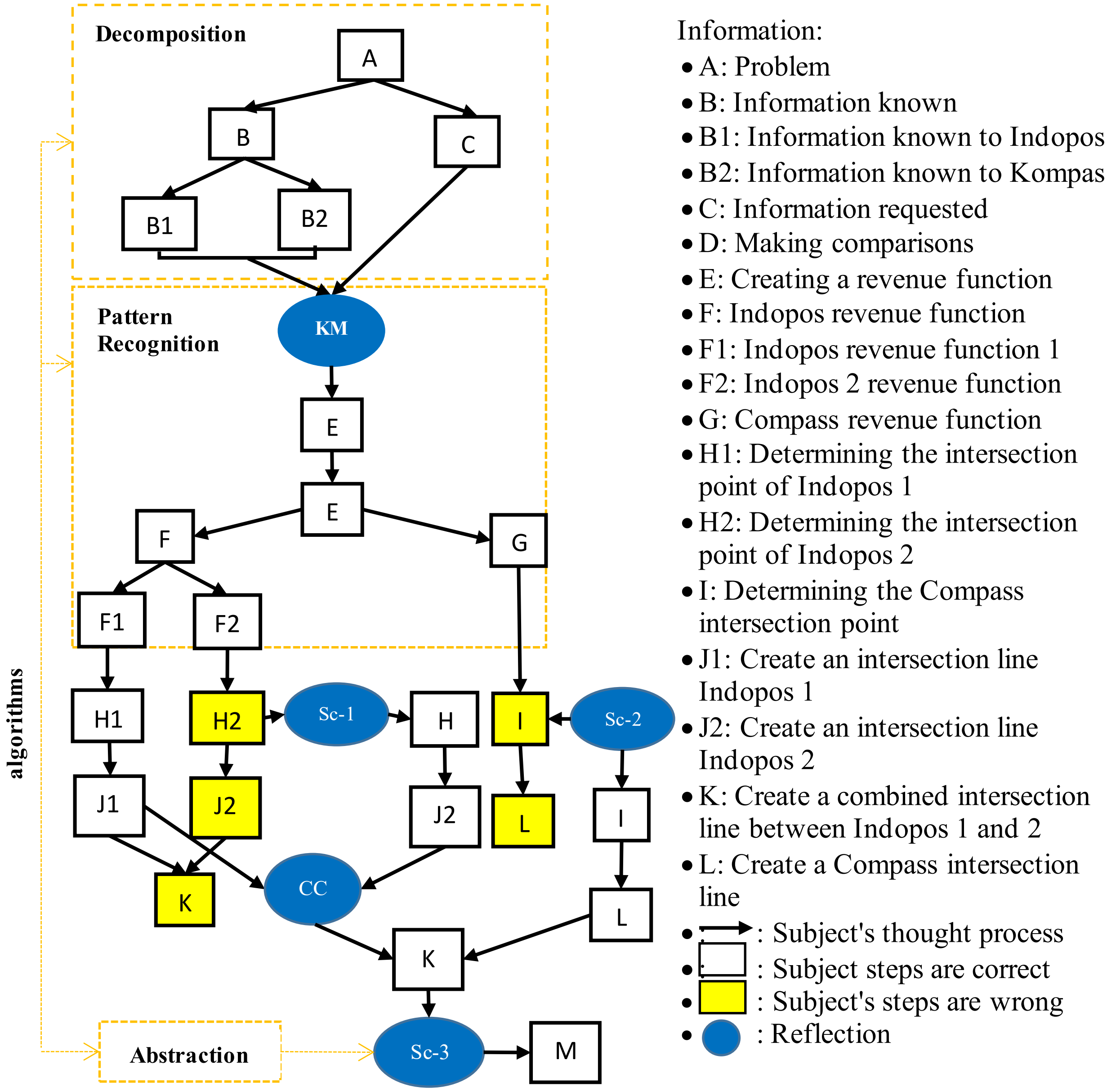
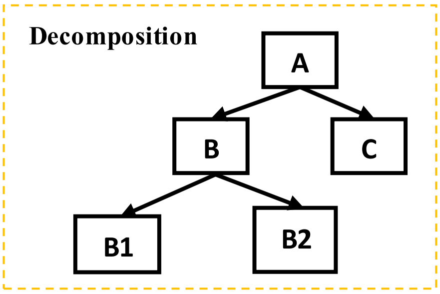


Figure 3. S1 Computational Thinking Process in Solving Mathematical Problems During Reflection

Transformation of Computational Thinking Process Subject S2

The computational thinking process of S2 in solving mathematical problems before reflection can be seen in Figure 4.



Information:
- A: Problem
- B: Information known
- B1: Information known regarding Indopos
- B2: Information known regarding Kompas
- C: Information requested

Figure 4. S2 Computational Thinking Process in Solving Mathematical Problems Before Reflection

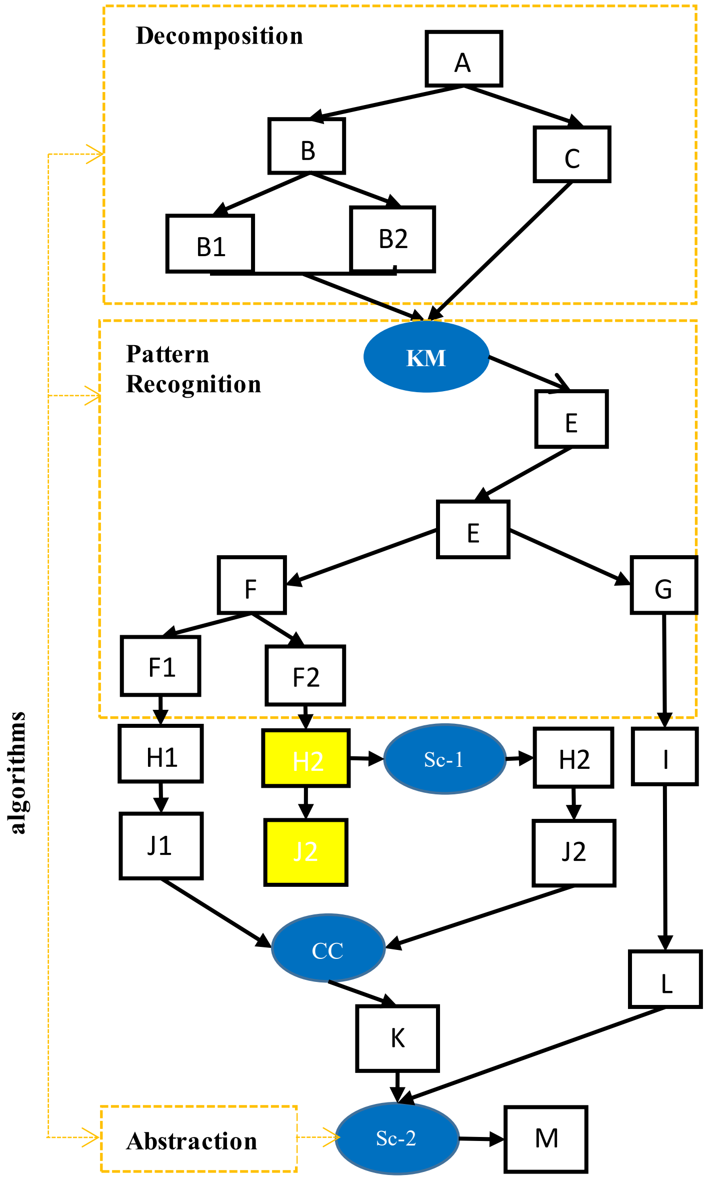
When solving linear programming problems before being given reflection, S2 showed limited initial abilities. At the decomposition stage, he was able to mention important information from the problem, such as the amount of hourly income from two media companies and a fixed bonus from Indopos, but was not yet able to link the information to the problem structure. S2 appeared to copy data from the problem without further decomposing it into a mathematical model. This shows that assimilation occurred, but was not accompanied by appropriate cognitive involvement.

After being given reflection, namely through trigger questions such as: "What shows the advantages of each job?", "Try to pay attention to income if working hours increase, how does it change?", and guidance in reviewing graphs and functions. S2 began to show significant transformation. Initially, S2 improved the income function by writing it correctly, namely the Indopos function: $y = 20x + 100$, and Kompas: $y = 25x$. This is an early indicator that accommodation has occurred because S2 began to form a new scheme to represent the relationship between variables mathematically.

Next, at the pattern recognition stage, S2 re-created the graph by taking into account points such as (0, 100), (4, 180), and (5, 200) for Indopos, and (0, 0), (4, 100), (5, 125) for Kompas. This graph is presented with a more structured axis and scale. Students then realized that the graphs of the two functions had an intersection at a certain point, and from there began to draw a pattern that the advantage of income shifted depending on the number of working hours.

At the abstraction stage, S2's transformation became clearer. He concluded that Kompas workers are more profitable if working hours exceed 4 hours, while Indopos is more profitable if working hours are less than that. This conclusion is written concisely in the reflective answer and is evidence that S2 has filtered information from graphs and functions into general statements. This process marks the change from concrete to abstract thinking, the main sign of cognitive accommodation that occurs.

Finally, in the algorithms stage, S2 rewrites the entire problem-solving procedure starting from forming functions, determining points, and drawing graphs, to concluding. This sequence shows a systematic thinking that S2 did not previously have. So that the post-reflection shows that S2 not only understands the material but also begins to master problem-solving strategies based on mathematical logic. Thus, the transformation of the computational thinking scheme has been formed. To make it easier, S2's computational thinking process in solving mathematical problems during reflection can be seen in Figure 5.

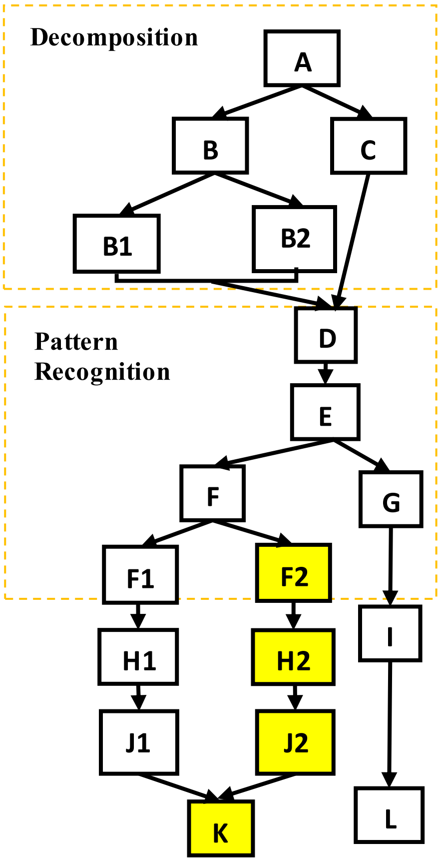


Information:
- A: Problem
- B: Information known
- B1: Information known to Indopos
- B2: Information known to Kompas
- C: Information requested
- D: Making comparisons
- E: Creating a revenue function
- F: Indopos revenue function
- F1: Indopos revenue function 1
- F2: Indopos 2 revenue function
- G: Compass revenue function
- H1: Determining the intersection point of Indopos 1
- H2: Determining the intersection point of Indopos 2
- I: Determining the Compass intersection point
- J1: Create an intersection line Indopos 1
- J2: Create an intersection line Indopos 2
- K: Create a combined intersection line between Indopos 1 and 2
- L: Create a Compass intersection line
- : Subject's thought process
- : Subject steps are correct
- : Subject's steps are wrong
- : Reflection

Figure 5. S2 Computational Thinking Process in Solving Mathematical Problems During Reflection

Transformation of Computational Thinking Process Subject S3

Data on the computational thinking process of S3 in solving mathematical problems before reflection can be seen in Figure 6.



Information:

- A: Problem
- B: Information known
- B1: Information known regarding Indopos
- B2: Information known regarding Kompas
- C: Information requested
- D: Making comparisons
- E: Creating a revenue function
- F: Indopos revenue function
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- G: Compass revenue function
- H1: Determining the intersection point of Indopos 1
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- J1: Create an intersection line Indopos 1
- J2: Create an intersection line Indopos 2
- K: Create a combination of intersecting lines
  Indopos 1 and 2
- L: Create a Compass intersection line
- → : Subject's thought process
- ☐ : Subject steps are correct
- ■ : Subject's steps are wrong

Figure 6. S3 Computational Thinking Process in Mathematical Problem Solving Before Reflection

Before being given reflection, S3 showed quite good mastery at the decomposition stage. He was able to identify important information from the question, such as type of work, hourly income, and fixed allowance. This is reflected in the initial answer fragment which lists the value of x as the number of hours worked and y or $f(x)$ as total income. Decomposition is done through assimilation because the information is successfully integrated into the cognitive scheme that S3 already has.

At the pattern recognition stage, S3 has begun to show efforts to connect the variable of working hours with income. He wrote two functions: Indopos $y =$

$20x + 100$ and Kompas $y = 25x$, and made a graph even though it was not precise. However, it appears that the graph is not yet precise, the scale is not consistent, and the intersection point is not determined numerically. This shows that the pattern has been recognized intuitively, but has not been fully concluded logically.

For the abstraction indicator, it has not been met either, S3 has not filtered the information into a conclusion. S3 does not clearly state at what time the income of the two jobs becomes the same or different. There is no verbal or numerical description of the implications of the shape of the graph. This shows that even though the strategy is in place, there has been no conceptual simplification of data to abstract understanding.

At the algorithms stage, the solution steps are still not systematic. S3 compiles functions and draws graphs, but does not follow up with logical procedures to conclusions. The steps tend to be incomplete, graphs are made without narratives, and conclusions are general without analysis of common ground. This shows limitations in sequencing problem-solving strategies computationally.

After being given reflection, namely in the form of trigger questions such as "What is the meaning of the intersection point of the two graphs?" and "What conclusions can be drawn from the shape of the graph?", significant changes occurred. S3 improved the graph, determined the intersection point of the two lines, and included a critical point when $x = 4$, where the income of both jobs is the same. This shows transformation through accommodation in recognizing patterns and creating more accurate visualizations.

At the abstraction stage, S3 wrote the conclusion that Indopos workers are more profitable if they work less than 4 hours, while Kompas is more profitable if they work more than that. This conclusion is based on graphs and functions and shows that he is able to filter information into general statements. This is a key indicator that an abstract thinking scheme has been formed and strengthened through reflection.

At the algorithms stage, S3 arranged the steps sequentially starting from compiling functions, determining points, drawing graphs, analyzing meeting points, to concluding. He explained narratively that the comparison of income depends on working hours, showing that his thinking algorithm was systematic. Evidence of the transformation of S3's computational thinking process is in Figure 7.

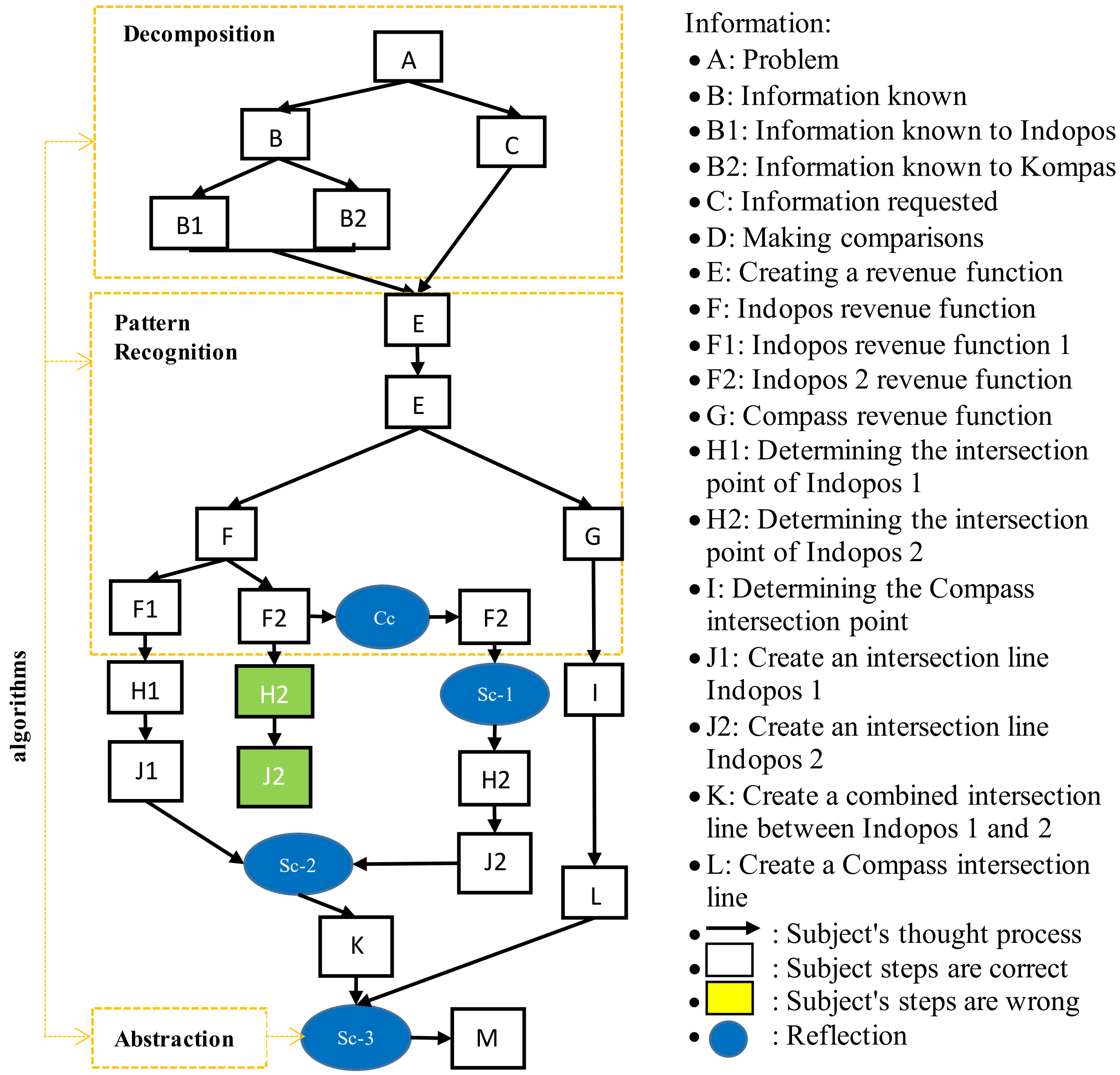
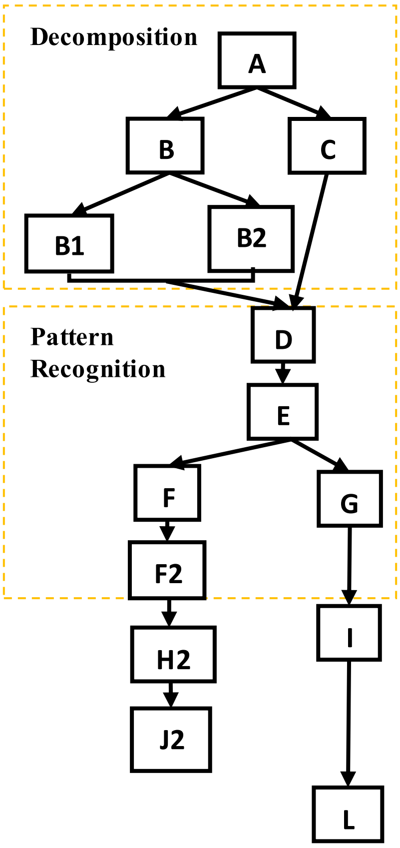


Figure 7. S3 Computational Thinking Process in Solving Mathematical Problems During Reflection

Transformation of Computational Thinking Process Subject S4

Data on the computational thinking process of S4 in solving mathematical problems before reflection can be seen in Figure 8.



Information:
- A: Problem
- B: Information known
- B1: Information known regarding Indopos
- B2: Information known regarding Kompas
- C: Information requested
- D: Making comparisons
- E: Creating a revenue function
- F: Indopos revenue function
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- J2: Create an intersection line Indopos 2
- K: Create a combination of intersecting lines
  Indopos 1 and 2
- L: Create a Compass intersection line
- $\longrightarrow$: Subject's thought process
- □ : Subject steps are correct
- ■ : Subject's steps are wrong

Figure 8. S4 Computational Thinking Process in Mathematical Problem Solving Before Reflection

Based on Figure 8, at the decomposition stage, S4 was able to identify the information known from the problem quite completely. He wrote that Indopos workers receive a basic salary of IDR 100,000 and a bonus of IDR 20,000 per hour of work, while Kompas workers receive IDR 25,000 per hour without a fixed bonus. This information is sorted and written in an orderly manner. This shows that assimilation has occurred because S4 can integrate the problem information into his cognitive structure.

Furthermore, at the pattern recognition stage, S4 began to write the mathematical function of the problem given, although only one function was written completely, namely the income function of Indopos workers. Meanwhile, the function for Kompas workers' income was not written. The graph created only contains one line and does not show a comparison between the two newspaper mass media. This shows that pattern recognition is only done partially and is not complete. S4's cognitive scheme at this stage is still incomplete, and accommodation has not occurred completely.

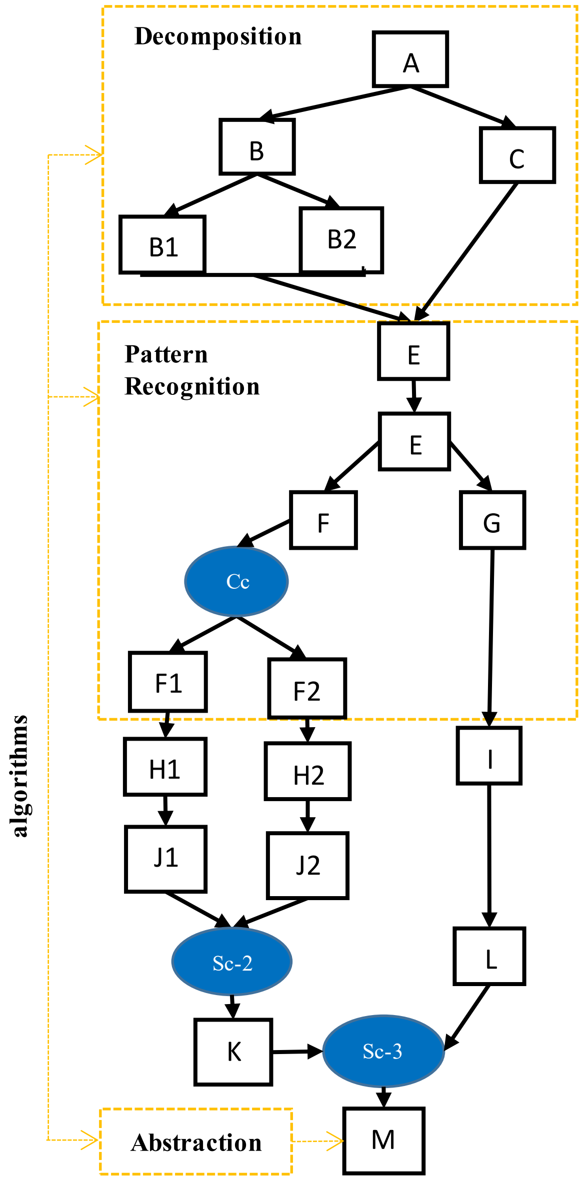
The abstraction indicator has also not been optimally fulfilled. S4 does not draw general conclusions from the available data. S4 does not show the meeting point between the graphs or conclude the profitable time interval for each job in both mass media. So the conclusions made are normative, such as "Indopos workers have higher salaries", without any mathematical explanation. This shows that there has been no process of filtering information or formulating the main idea from the data available.

Likewise, in algorithms, S4 has not systematically compiled the steps to solve the problem. Functions, graphs, and conclusions are not presented in a logical order. Some steps are skipped, such as calculating the coordinate points for the graph. The graphs created also do not consider the correct scale and axis. This solution shows that S4 is still using a trial-and-error strategy and does not yet have a good algorithmic scheme.

After being given reflection, namely with questions such as "What will happen if working hours are increased?" or "How do you know who is more profitable after a certain hour?", S4 began to show changes in his way of thinking. He improved and completed the previously missing functions, so now he wrote the Indopos function: $y = 20x + 100$, and the Kompas income function: $y = 25x$. Then S4 calculated the income points and made a graph of both functions. This shows that reflection successfully encouraged accommodation at the pattern recognition stage, where S4 formed a new scheme to understand and compare graphs as a whole.

The abstraction stage also transformed. S4 concluded that the graph intersection occurred at the 4th working hour. He stated that if working less than 4 hours then Indopos is more profitable, while if more than 4 hours then Kompas has a higher income. This conclusion was written in words and based on observations of the graph and function. This is evidence that abstraction has been formed, and S4 is able to filter information into general ideas that are applicable.

At the algorithms stage, S4 arranged the solution in a coherent order, starting from describing important information, modeling, forming functions, determining values, drawing graphs, to concluding. S4 added logical descriptions to support the solution steps. This shows that S4 can create consistent visual and verbal representations. This shows that his algorithmic scheme has been formed through accommodation, the result of a reflection process that leads students to reconstruct the solution steps. A picture of the transformation of S4's computational thinking process during reflection can be seen in Figure 9.



Information:
- A: Problem
- B: Information known
- B1: Information known to Indopos
- B2: Information known to Kompas
- C: Information requested
- D: Making comparisons
- E: Creating a revenue function
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- J1: Create an intersection line Indopos 1
- J2: Create an intersection line Indopos 2
- K: Create a combined intersection line between Indopos 1 and 2
- L: Create a Compass intersection line
- → : Subject's thought process
- : Subject steps are correct
- : Subject's steps are wrong
- : Reflection

Figure 9. S4 Computational Thinking Process in Solving Mathematical Problems During Reflection

Overall, the transformation of the computational thinking process of the four subjects occurred through accommodation in the final three stages, while the decomposition stage occurred through assimilation. This transformation shows that reflection is not only effective for low-ability students, but is also very useful in strengthening and completing the thinking process of medium-ability students so that the solution strategy becomes more complete and meaningful.

Table 2. Transformation of Computational Thinking Processes of Low and Medium Ability Subjects

Subject	Indicator	Before Reflection	After Reflection	Types of Transformation
S1	Decomposition	Identify basic information well	Still good; no significant changes	Assimilation
	Pattern Recognition	Does not recognize relationships between variables; graph is not logical	Constructing correct graphs and mathematically relating variables	Accommodation
	Abstraction	Does not summarize or filter information; answers are descriptive.	Conclude that the point of intersection of the graph indicates the advantage of work after a certain hour.	Accommodation
	Algorithms	The steps are unsystematic and incomplete	Arrange functions, graphs, and conclusions logically and sequentially	Accommodation
S2	Decomposition	Found some information, but not complete	Able to write down all important information after being given directions	Assimilation
	Pattern Recognition	Graphs are made without reference; there is no apparent understanding of the relationships between variables.	The graph is fixed; the points are calculated and arranged in a linear graph.	Accommodation
	Abstraction	Unable to simplify information; does not mention points of intersection	Summarizing optimal income conditions based on working hours	Accommodation
	Algorithms	The solution is not sequential and not coherent	Complete procedure from function → graph → Conclusion	Accommodation

Subject	Indicator	Before Reflection	After Reflection	Types of Transformation
S3	Decomposition	Identify information and variables correctly	Still strong, no significant changes	Assimilation
	Pattern Recognition	Recognize patterns intuitively, but charts are not yet precise	The graph is refined with intersection points; the relationships between variables are clarified.	Assimilation → Accommodation
	Abstraction	Not concluding in general	Able to draw generalizations based on function intersection points	Accommodation
	Algorithms	The thinking steps are not yet coherent and are still fragmentary.	Arrange the solution systematically with explanatory narrative	Accommodation
S4	Decomposition	State all the information about the question clearly	Still going strong, still without any significant changes	Assimilation
	Pattern Recognition	Only one function is created; graph is incomplete	Write two functions and graph the two lines with clear points of intersection.	Assimilation → Accommodation
	Abstraction	Does not conclude or compare results numerically	Summarizing job advantages based on working hour intervals	Accommodation
	Algorithms	The steps are incomplete and the order is random.	Arrange the sequence of procedures from beginning to conclusion logically	Accommodation

The findings of this study indicate that reflection can transform students' computational thinking processes, especially in the indicators of pattern recognition, abstraction, and algorithmic thinking. This transformation process occurs through the mechanism of cognitive accommodation, namely when students change or form new thinking schemes in response to challenging problem-solving situations. Conversely, at the decomposition stage, students tend to experience assimilation, because they are quite capable of understanding and describing information from contextual problems directly based on existing initial schemes. These results support Piaget's theory (1970) which states that meaningful learning occurs when individuals experience cognitive imbalances that trigger the reorganization of thinking structures through the processes of assimilation and accommodation.

An important implication of these results is that reflecting on mathematics learning is not only effective for low-ability students, but also strengthens the understanding of medium-ability students. This is in line with Susanti's opinion (2021), that reflection is an important component in professional learning, where individuals actively review and evaluate the way of thinking and strategies used in a task. In the context of computational thinking, reflection can help students review how they break down problems (decomposition), recognize patterns and models (pattern recognition), filter important information (abstraction), and systematically construct step-by-step solutions (algorithms) (Wing, 2014).

These findings have high relevance for practical application in mathematics learning in the classroom. Educators can design structured reflective activities, such as inserting trigger questions in student worksheets: "What do you not understand from the steps you took?" or "How do you know that the solution you chose is the most appropriate?" These questions lead students to carry out metacognitive processes, which have been shown to strengthen connections and understanding of mathematical concepts (Schoenfeld, 1992). In addition, teachers can apply think-aloud strategies and guided discussions to get students used to exploring and reflecting on the reasons behind the steps they take to solve problems.

Teachers can also encourage the use of visual representations such as graphs, sketches, or mathematical models because visualizations greatly help students recognize patterns and make abstractions. This follows the view of

Gravemeijer & Doorman (1999) in the Realistic Mathematics Education approach, which emphasizes the importance of models and contextual representations in building meaningful mathematical understanding. In this study, the graphical representation of two linear functions from the work context successfully helped students conclude the relationship between variables.

To support the success of reflection in mathematics learning, it is also important for teachers to build a classroom culture that accepts mistakes as part of the learning process. Muhtadin (2020) explains that in a growth mindset, mistakes are not failures, but opportunities to improve strategies and form deeper understandings. Reflection will work optimally if students feel psychologically safe to review and revise their thinking without fear of being judged badly. Therefore, teachers need to create a collaborative learning environment, be open to questions and appreciate students' thinking processes.

CONCLUSION

The study's findings, which were derived from data analysis and discussion, indicate that while accommodation takes place in the phases of pattern recognition, abstraction, and algorithmic thinking, assimilation happens in the decomposition indicator for students with low abilities. This fact is based on the finding that students are able to simplify problems and need reflection to recognize patterns, apply patterns, make conclusions, and complete algorithms. Then students with moderate abilities experience assimilation on the indicators of decomposition and pattern recognition, while accommodation occurs on the indicators of abstraction and algorithmic thinking. This is because students are able to simplify problems and relate mathematical material to problems, but in carrying out plans, they need reflection to correct errors using patterns, make inferences about answers, and complete algorithms. As a result, in this study, reflection can stimulate the transformation of students' computational thinking from the pattern recognition stage to the abstraction and algorithm thinking stages.

REFERENCES

Agbo, F. J., Okpanachi, L. O., Ocheja, P., Oyelere, S. S., & Sani, G. (2024). How can unplugged approach facilitate novice students' understanding of computational thinking? An exploratory study from a Nigerian university. *Thinking Skills and Creativity*, *51*, 101458. https://doi.org/10.1016/j.tsc.2023.101458

Angeli, C., & Giannakos, M. (2020). Computational thinking education: Issues and challenges. *Computers in Human Behavior*, *105*. https://doi.org/10.1016/j.chb.2019.106185

Brackmann, C. P., Moreno-León, J., Román-González, M., Casali, A., Robles, G., & Barone, D. (2017). Development of computational thinking skills through unplugged activities in primary school. *ACM International Conference Proceeding Series*, 65–72. https://doi.org/10.1145/3137065.3137069

Cahdriyana, R. A. (2020). *Berpikir Komputasi Dalam Pembelajaran Matematika*. *XI*(1), 33–35.

Città, G., Gentile, M., Allegra, M., Arrigo, M., Conti, D., Ottaviano, S., Reale, F., & Sciortino, M. (2019). The effects of mental rotation on computational thinking. *Computers and Education*, *141*(June), 0–10. https://doi.org/10.1016/j.compedu.2019.103613

Dorko, A. (2019). *Generalization, Assimilation, and Accommodation*. *28*(2), 33–51.

Gog, T. Van, Hoogerheide, V., & Harsel, M. Van. (2020). *The Role of Mental Effort in Fostering Self-Regulated Learning with Problem-Solving Tasks*.

Hamdani, D., Subarinah, S., & Triutami, T. W. (2021). *Construction Scheme of Proof Based on Assimilation and Accommodation Processes: Theorem of Number Theory*. https://doi.org/10.1088/1742-6596/1776/1/012004

Harsa Wara Prabawa, & H. R. S. M. (2019). Peningkatan Kemampuan Berpikir Komputasi Siswa Melalui Multimedia Interaktif Berbasis Model Quantum Teaching and Learning. *International Journal of Computer Science Education in Schools*, *8*(1), 41. https://doi.org/10.13140/RG.2.2.34438.83526

Jalan, S., Nusantara, T., Subanji, S., & Chandra, T. D. (2016). *Students ' thinking process in solving combination problems considered from assimilation and accommodation framework*. *11*(16), 1494–1499. https://doi.org/10.5897/ERR2016.2811

Kang, C., Liu, N., Zhu, Y., Li, F., & Zeng, P. (2023). Developing College students' computational thinking multidimensional test based on Life Story situations. *Education and Information Technologies*, *28*(3), 2661–2679. https://doi.org/10.1007/s10639-022-11189-z

M. Gunawan Supiarmo, Liny Mardhiyatirrahmah, T. (2021). Pemberian Scaffolding untuk Memperbaiki Proses Berpikir Komputasional Siswa dalam Memecahkan Masalah Matematika. *Jurnal Cendekia*, *05*(01), 368–382.

Montuori, C., Gambarota, F., Altoé, G., & Arfé, B. (2024). The cognitive effects of computational thinking: A systematic review and meta-analytic study. *Computers & Education*, *210*, 104961. https://doi.org/10.1016/j.compedu.2023.104961

Muhtadin, A. (2020). Defragmenting Struktur Berpikir Melalui Refleksi untuk Memperbaiki Kesalahan Siswa Menyelesaikan Soal Cerita. *Jurnal Primatika*, *9*, 25–34.

Novita Ainurrohmah, & N. M. (2016). Refleksi Kritis Terhadap Pandangan Matematika dari Perspektif Siswa dan Pendidik Sekolah Dasar. *Jurnal Pendidikan Guru Sekolah Dasar*, *6*, 1706–1717.

Subanji. (2015). *Teori Kesalahan Konstruksi Konsep dan Pemecahan Masalah Matematika*.

Supiarmo, M. G. (2021a). Defragmenting Studentâ€™s Thinking Structures in Solving Mathematical Problems on PISA Model. *(JIML) JOURNAL OF INNOVATIVE MATHEMATICS LEARNING*, *4*(4), 167–177. https://doi.org/10.22460/jiml.v4i4.p167-177

Supiarmo, M. G. (2021b). Defragmenting Student's Thinking Structures in Solving Mathematical Problems on Pisa Model. *(JIML) Journal of Innovative Mathematics Learning*, *4*(4), 167–177.

Supiarmo, M. G. (2021c). *Transformasi proses berpikir komputasional siswa sekolah menengah atas pada pemecahan masalah matematika melalui refleksi* [Masters, Universitas Islam Negeri Maulana Malik Ibrahim].

Susanti, E. (2021). *The reflection strategies on students' thinking structures in the mathematical problem solving steps*.

Triantafyllou, S. A., Sapounidis, T., & Farhaoui, Y. (2024). Gamification and Computational Thinking in Education: A systematic literature review. *Salud, Ciencia y Tecnología - Serie de Conferencias*, *3*, 659. https://doi.org/10.56294/sctconf2024659

Utami, P., Karolina, A., & Apriani, E. (2024). *Penerapan Model Project Based Learning (PjBL) Untuk Mengembangkan Critical Thinking dan Computational Thinking Skill Mahasiswa PAI Pascasarjana IAIN CURUP* [Masters, Institut Agama Islam Negeri Curup].

Wing, J. (2014). Computational thinking benefits society. *Journal of Computing Sciences in Colleges*, *24*(6), 6–7. https://doi.org/10.1145/1227504.1227378

Yilmaz, R., & Karaoglan Yilmaz, F. G. (2023). The effect of generative artificial intelligence (AI)-based tool use on students' computational thinking skills, programming self-efficacy and motivation. *Computers and Education: Artificial Intelligence*, *4*, 100147. https://doi.org/10.1016/j.caeai.2023.100147