

Computational Thinking in Solving PISA Quantity Problems: A Study of Junior High School Students' Numeracy Ability

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ABSTRACT

Technological developments and the complexity of problems in the contemporary era require students to not only master mathematical steps but also to be able to think logically and systematically in solving contextual problems. Computational thinking is closely related to numeracy skills because it requires the ability to understand quantitative information, analyze relationships between data, and design structured and logical problem-solving steps. This study aims to analyze students' computational thinking skills in solving PISA questions based on quantity in terms of numeracy skills. The research used a descriptive qualitative approach conducted at SMPIT Al-Falaah Simo in the odd semester with eighth-grade students as subjects. Data collection was conducted through tests and interviews, using instruments in the form of numeracy tests, PISA Quantity content tests, and interview guidelines. The results of the study indicate that variations in numeracy skills have an impact on the quality of students' computational thinking. Students with high numeracy skills are able to fulfill all indicators of computational thinking, namely decomposition, pattern recognition, abstraction, and algorithms. Students with moderate numeracy skills fulfill these indicators but still have limitations in problem solving. Meanwhile, students with low numeracy skills are not yet able to fully fulfill the indicators of computational thinking.

Keywords: PISA, Computational thinking, Numeracy, SPLDV

Berpikir Komputasional dalam Memecahkan Soal Kuantitas PISA: Studi Kemampuan Numerasi Siswa Sekolah Menengah Pertama

ABSTRAK

Perkembangan teknologi dan kompleksitas masalah di era kontemporer mengharuskan siswa tidak sekadar menguasai langkah-langkah matematis, melainkan juga dapat berpikir logis dan sistematis dalam memecahkan permasalahan kontekstual. *Computational thinking* berkaitan erat dengan kemampuan numerasi karena menuntut kemampuan memahami informasi kuantitatif, menganalisis hubungan antar data, dan merancang langkah pemecahan masalah secara terstruktur dan logis. Penelitian ini bertujuan untuk menganalisis kemampuan *Computational Thinking* siswa dalam menyelesaikan soal PISA konten *Quantity* ditinjau dari kemampuan numerasi. Penelitian menggunakan pendekatan kualitatif deskriptif yang dilaksanakan di SMPIT Al-Falaah Simo pada semester ganjil

dengan subjek siswa kelas VIII. Pengumpulan data melalui tes dan wawancara, menggunakan instrumen berupa tes numerasi, tes PISA konten *Quantity*, dan pedoman wawancara. Hasil penelitian menunjukkan bahwa variasi dalam ketrampilan numerasi berdampak pada kualitas *Computational Thinking* siswa. Siswa dengan kemampuan numerasi tinggi mampu memenuhi seluruh indikator berpikir komputasi yaitu dekomposisi, pengenalan pola, abstraksi, dan algoritma. Siswa dengan kemampuan numerasi sedang memenuhi indikator tersebut namun masih memiliki keterbatasan dalam penyelesaian masalah. Sementara siswa dengan kemampuan numerasi rendah belum mampu memenuhi indikator berpikir komputasi secara utuh.

Kata Kunci: PISA, Numerasi, *Computational Thinking*, SPLDV

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1. Introduction

The development of information and communication technology in the era of the Industrial Revolution 4.0 is accelerating, bringing changes to various aspects of life, including education (Mulyani & Haliza, 2021). These changes require individuals to have high thinking skills to prepare students to face complex challenges in the future. One of the 21st-century skills that must be mastered to compete in this advancement is Computational Thinking (CT) (Alimuddin et al., 2023).

Computational thinking is defined as a systematic and logical way of thinking, similar to the programming process (Su & Yang, 2023). Computational thinking skills are not only inherent in the field of computer science but also extend to various other domains, such as mathematical learning (Subramaniam et al., 2022). In mathematics learning, computational thinking is often used to help solve problems systematically and structurally (Marethi et al., 2024). There are four indicators of computational thinking Safitri et al. (2024), namely: (1) Decomposition, which is breaking down large problems into smaller parts that are easier to solve, (2) Pattern recognition, which is recognizing similarities and differences in data and problems, (3) algorithmic thinking (developing steps to solve problems), (4) abstraction (identifying important information and ignoring unrelated things). In addition, computational thinking helps in building deep thinking strategies, improving mathematical thinking skills, and solving contextual problems which are important components in learning.

Students' mathematical abilities are now measured not only through procedural knowledge but also through their ability to apply mathematical concepts to solve real-world problems (Cahdriyana & Richardo, 2020). The Programme for International Student Assessment (PISA) is an international assessment program organized by the OECD (Ratu, 2019) to measure students' ability to apply mathematical knowledge in everyday contexts. In the mathematics domain, the content of quantity is a major focus because it measures students' mastery of the dynamics of change and quantitative relationships in real contexts (Hasanah & Hakim, 2022). This content is closely related to numeracy skills, which are the ability to use mathematical knowledge contextually to reason and solve problems in everyday life (Mashuri et al., 2023).

According to the [OECD \(2019\)](#) numeracy in PISA is defined as an individual's ability to reason systematically and utilize mathematical concepts, procedures, and tools to describe, explain, and predict a phenomenon ([Nur et al., 2022](#)). In the context of PISA, numeracy is very important because around 35% of PISA mathematics questions focus on quantity content that requires quantitative understanding, such as ratios, percentages, and scales ([OECD, 2021](#)). Quantity content makes numeracy the main foundation for solving contextual problems, which in practice requires the support of computational thinking processes such as problem solving, pattern identification, abstraction, and step planning ([Supiarmo et al., 2021](#); [Saputri & Setyaningsih, 2024](#)). Computational thinking provides a strong framework to support numeracy in the context of contextual problem solving so that students can not only perform calculations but also think critically and reflectively about how to solve problems ([Sopamena et al., 2023](#)).

While CT research in mathematics education is expanding, the majority of studies continue to concentrate on the implementation of technology-enhanced learning or the creation of instructional resources ([Ye et al., 2023](#)). Some research has also investigated CT components in conjunction with other cognitive skills, including creativity and problem-solving ([Amalia et al., 2025](#); [Azizia et al., 2023](#); [González et al., 2017](#)). However, few studies have specifically examined how students' CT abilities are reflected in solving PISA quantity content questions based on different levels of numeracy. Research on computational thinking in the context of assessment is still dominated by the development of conceptual frameworks and policy implementation recommendations ([Bacconi et al., 2016](#)). This research has not specifically observed how students' computational thinking processes are reflected in solving PISA contextual questions, especially based on differences in numeracy skills. Furthermore, although PISA mathematical literacy and numeracy skills have been widely discussed in various studies, there are still few studies that explicitly explore the relationship between computational thinking indicators and numeracy skills in solving PISA quantity content questions ([Nouri et al., 2020](#)). Nevertheless, various studies show that computational thinking skills play an important role in solving complex mathematical problems. These skills help in understanding complex information, recognizing patterns, and designing structured solution steps ([Afidatunisa & Juandi, 2024](#); [Yadav et al., 2014](#)).

Thus, there is still a gap in research related to the analysis of students' computational thinking processes in solving PISA quantity content questions based on differences in numeracy levels (high, medium, and low). Based on this gap, the research question in this study is how students' computational thinking indicators, which include decomposition, pattern recognition, algorithms, and abstraction, are reflected in solving PISA quantity content questions, and how the characteristics of these indicators differ among students with high, medium, and low levels of numeracy. Therefore, this study aims to explain and examine the CT indicators (decomposition, pattern recognition, algorithms, and abstraction) when solving PISA-based quantity problems for students with high, medium, and low numeracy levels. The results of this study are expected to contribute to the development of more contextual and CT-based mathematics learning strategies, as well as to form the basis for education policies that are relevant to global demands.

2. Method

This research is a qualitative study using a descriptive approach to obtain descriptive data in the form of an in-depth description of students' computational thinking abilities in solving PISA questions on quantity, reviewed from the perspective of numeracy ability (high, medium, and low). The subjects of this study were eighth-grade students at SMPIT Al-Falaah Simo who had

high, medium, and low numeracy abilities, with one student selected from each category based on teacher input.

The data used in this study included primary and secondary data. The primary data from this study were the results of the PISA quantity content questions, while the secondary data were the results of the numeracy questions conducted before the study began. The instruments used were numeracy tests, PISA tests adapted from the 2012 mathematics released items, and semi-structured interview guides. The following are the PISA quantity content questions. PISA question on quantity “*A merchant makes fruit compote from apples and mangoes. To maintain the same flavor, the merchant always uses the following recipe: 750 ml of compote is made from 2,5 apples and 2 mangoes. One day, the vendor successfully produced 3750 ml of pickles, utilizing all the prepared apples and mangoes. If the total number of fruits (apples and mangoes) used was 22,5 then how many apples and mangoes did the vendor use?*”.

This research procedure consists of four stages. The first stage begins with giving students numeracy questions as a diagnostic assessment, with the results grouped into three categories: high, medium, and low numeracy skills. In the second stage, students are given PISA quantity content questions based on the PISA framework. These questions focus on quantitative problems that involve two-variable linear equation systems (SPLDV). Students are evaluated on their ability to think computationally when they solve these problems. The computational thinking indicators according to (Helsa et al., 2023) used in this study are presented in Tabel 1. In the third stage, the researchers conducted triangulation to validate the analysis results through interviews with one student in each numeracy category. Next, the researchers compared the computational thinking abilities of students across numeracy categories.

Tabel 1. Computational Thinking Indicators

Indicators	Computational thinking sub-indicators
Decomposition	Able to break down information into smaller parts, identify important elements in questions related to numeracy concepts
Pattern recognition abstract	Finding patterns or regularities in problems Simplifying problems into systematic forms, creating mathematical models
Algorithm	Developing systematic steps, using procedures or algorithms correctly

3. Result and Discussion

Based on the numeracy test results, the research subjects were categorized into high, medium, and low numeracy. The high, medium, and low categories are listed in Table2.

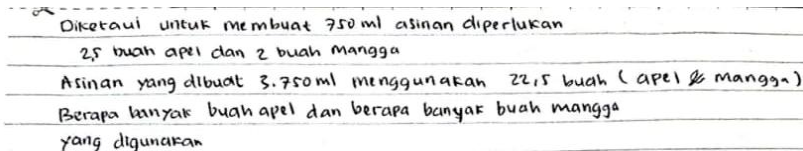
Table 2. Numeracy Categories

Categories	Average Score
High	> 93,4
Medium	≤93,4 and >70,35
low	<70,35

Based on this classification, there were 4 students with high numeracy skills, 7 students with moderate skills, and 6 students with low skills. The subjects were determined based on input from the teacher, so the study took one student with high numeracy skills (S1), one student with moderate numeracy skills (S2), and one student with low numeracy skills (S3). The results of the analysis of numeracy skills in solving PISA quantity content questions in terms of computational thinking are described as follows:

3.1. Computational Thinking Process With High Numeracy Category (S1)

Based on the results of the work and interviews with S1 subjects on achieving the S1 computational thinking process from solving PISA questions on quantity content, they did not experience any difficulties. The following are the results of the work and interviews.

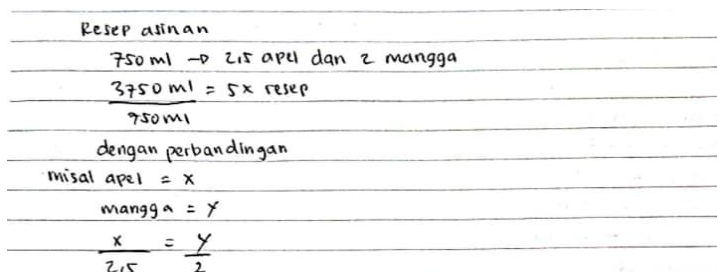


Diketahui untuk membuat 750 ml asinan diperlukan
2,5 buah apel dan 2 buah mangga
Asinan yang dibuat 3.750ml menggunakan 22,5 buah (apel & mangga)
Berapa banyak buah apel dan berapa banyak buah mangga
yang digunakan

Decomposition

It is known that, to make 750 ml of pickles, you need:
2.5 apples and 2 mangoes.
The pickles made from 3,750 ml used 22.5 fruits (apples and mangoes).
How many apples and mangoes were used?

Figure 1. S1 Decomposition Process

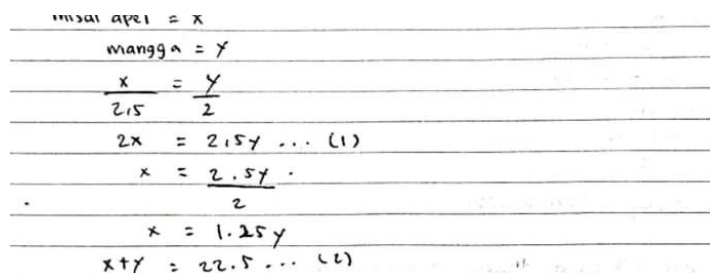


Resep asinan
750 ml $\rightarrow$ 2,5 apel dan 2 mangga
 $\frac{3750 \text{ ml}}{750 \text{ ml}} = 5 \times \text{resep}$
dengan perbandingan
misal apel = x
mangga = y
 $\frac{x}{2,5} = \frac{y}{2}$

Pattern recognition

Pickle recipe 750ml = 2,5 apples and 2 mangoes
 $\frac{3750 \text{ ml}}{750 \text{ ml}} = 5 \times \text{recipe}$
With the ratio
For example, apples = x
Mangoes = y
 $\frac{x}{2,5} = \frac{y}{2}$

Figure 2. Pattern Recognition Process S1



misal apel = x
mangga = y
 $\frac{x}{2,5} = \frac{y}{2}$
 $2x = 2,5y \dots (1)$
 $x = \frac{2,5y}{2}$
 $x = 1,25y$
 $x + y = 22,5 \dots (2)$

abstract

For example apples = x
Mangoes = y
 $\frac{x}{2,5} = \frac{y}{2}$
 $2x = 2,5y \dots (1)$
 $x = \frac{2,5y}{2}$
 $x = 1,25y$
 $x + y = 22,5 \dots (2)$

Figure 3. S1 Abstraction Process

Substitusi ke (2)	Substitusi ke (1)
$x + y = 22,5$	$x = 1,25y$
$(1,25y) + y = 22,5$	$x = 1,25(10)$
$2,25y = 22,5$	$x = 12,5$
$y = \frac{22,5}{2,25}$	
$y = 10$	
Jadi banyaknya buah yg dibutuhkan untuk membuat 3750 ml yaitu 12,5 buah apel dan 10 buah mangga.	

Algorithm

<p>Substitution to (2)</p> $x + y = 22,5$ $(1,25y) + y = 22,5$ $2,25y = 22,5$ $y = \frac{22,5}{2,25}$ $y = 10$	<p>Substitution to (1)</p> $x = 1,25y$ $x = 1,25(10)$ $x = 12,5$
<p>So, the amount of fruit used to make 3750ml is 12.5 apples and 10 mangoes.</p>	

The S1 answer was further reinforced by the following interview:

P : "In your opinion, what information is important in this question?"

S1: "The important thing is that the recipe for 750 ml of pickles requires 2.5 apples and 2 mangoes, so how many mangoes and apples are needed if the pickles to be made are 3750 ml and the total is 22.5 pieces?"

P : "Then what is the relationship between 750 ml and 3750 ml?" S1: "3750 ml is five times 750 ml, so the recipe is multiplied by five."

P : "How did you get that ratio equation and the equation $x + y = 22.5$?"

S1: "Because the ratio of apples to mangoes in the recipe is 2.5 to 2, I made x divided by 2.5 equal to y divided by 2, and $x + y = 22.5$ because the total number of apples and mangoes is 22.5."

P : "Can you explain the steps you took to arrive at your answer?"

S1: "First, I made a ratio, then I converted it into an equation to get the value of apples, which I labeled x , and for mangoes, I used substitution."

Based on the answers and interviews, it shows that subject S1 has a good ability to understand problems in the form of stories accurately, correctly, and clearly. This competence can be seen in Figure 1, where S1 is able to identify and separate problems according to known information and what is asked in the question. In addition, S1 sees in Figure 2 that there is more than one relationship between the known volume of pickles and the volume of pickles that needs to be made. After understanding this relationship, Figure 3 S1 simplifies the contextual problem into a mathematical model by assuming the number of apples as x and the number of mangoes as y . This stage reflects the ability to abstract and model mathematics appropriately. Based on the model that has been created, in Figure 4, S1 then systematically and structurally arranges the steps to solve the problem so as to obtain the correct final solution.

3.2. Computational Thinking Process with Moderate Numeracy Category (S2)

Based on the results of the work and interviews with S2 students in achieving the computational thinking process in solving PISA S2 questions, they have sufficient computational thinking skills, as can be seen below:

Diket: _____ Date: _____ No: _____
 resep asinan 750 ml membutuhkan 2,5 apel
 dan 2 buah mangga. Asinan yg dibuat 3.750 ml
 membutuhkan 22,5 mangga
 Dit: _____
 Berapa banyak buah apel dan mangga yg dibutuhkan

Decomposition

Known:
 A 750 ml pickle recipe requires 2,5 apples and 2 mangoes
 A 3750 ml pickle recipe requires 22.5 mangoes

Figure 5. S2 Decomposition Process

jawab: _____
 $\frac{3750}{750} = 5 \times \text{lipat dari resep asinan}$
 $\text{apel} = 2,5 \times 5 = 12,5$

Pattern recognition

answer:
 $\frac{3.750}{750} = 5 \text{ times the amount of the pickle recipe}$
 $\text{Apel} = 2,5 \times 5 = 12,5$

Figure 6. S2 Pattern Recognition Process

misal apel = x
 mangga = y
 $x + y = 22,5$

Abstract

example
 apples = x
 Mangoes = y
 $x + y = 22,5$

Gambar 7. S2 Abstraction Process

$x + y = 22,5$
 $12,5 + y = 22,5$
 $y = 22,5 - 12,5$
 $y = 10$
 jadi yg dibutuhkan untuk membuat 3750ml
 asinan 12,5 buah apel dan 10 buah mangga

Algoritma

$x + y = 22,5$
 $12,5 + y = 22,5$
 $y = 22,5 - 12,5$
 $y = 10$
 So, to make 3,750 ml of pickled fruit, you need 12.5 apples
 and 10 mangoes.

Gambar 8. Algorithm S2 Process

The S2 answer was further reinforced by the following interview:

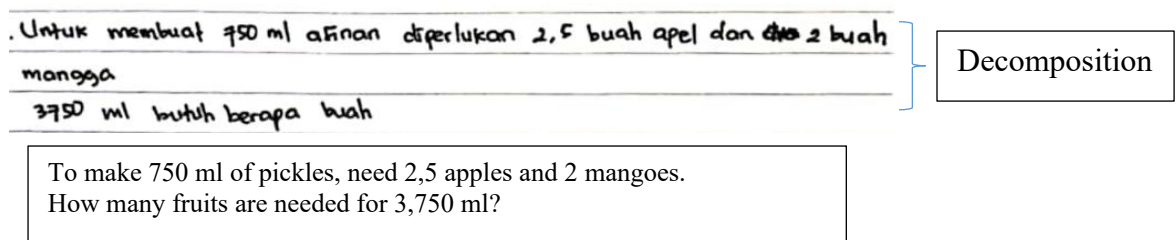
P : "How did you write the information in the question into a mathematical model?"

S2: "Actually, I was also confused, without a mathematical model, it could be 2.5 apples times 5 and 2 mangoes times 5. But I tried to make a mathematical model as best I could."

Based on the answers and interviews, Figure 5. Shows that subject S2 was able to sort important information and determine the purpose of the problem but was still limited to recording data. Furthermore, Figure 6 shows that S2 recognized the pattern of multiples between the recipe volume and the volume produced but did not recognize the pattern of comparison between apples and mangoes. This knowledge has an impact on the modeling stage, as seen in Figure 7 where subject S2 simplifies the problem into a single mathematical equation without creating a complete comparison model. However, in Figure 8 subject S2 compiles a sequence of steps to solve the problem but without explaining the reasoning behind each step.

3.3. Computational Thinking Process with Moderate Numeracy Category (S3)

Achievements in computational thinking in solving PISA S3 problems have poor computational thinking skills, as shown in the following image and interview results:



. Untuk membuat 750 ml acar diperlukan 2,5 buah apel dan 2 buah mangga
3750 ml butuh berapa buah

Decomposition

To make 750 ml of pickles, need 2,5 apples and 2 mangoes.
How many fruits are needed for 3,750 ml?

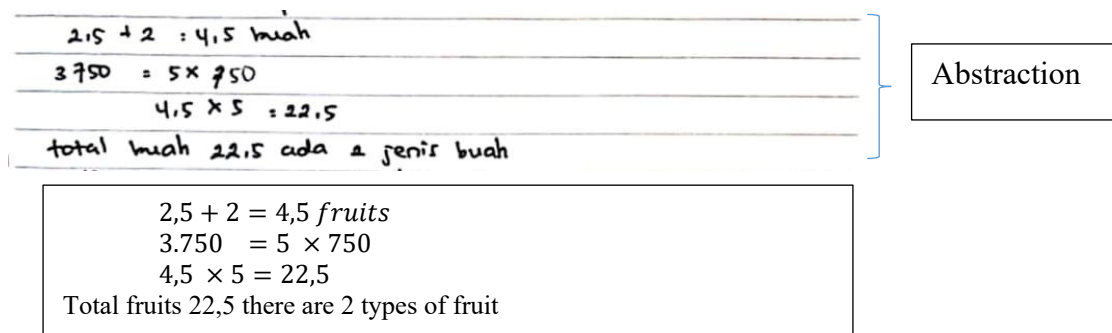
Figure 9. S3 Decomposition Process



$3750 = 5 \times 750$
 $4,5 \times 5 = 22,5$

Pattern Recognition

Figure 10. S3 Pattern Recognition Process



$2,5 + 2 = 4,5 \text{ buah}$
 $3750 = 5 \times 750$
 $4,5 \times 5 = 22,5$
total buah 22,5 ada 2 jenis buah

Abstraction

$2,5 + 2 = 4,5 \text{ fruits}$
 $3.750 = 5 \times 750$
 $4,5 \times 5 = 22,5$
Total fruits 22,5 there are 2 types of fruit

Figure 11. S3 Abstraction Process

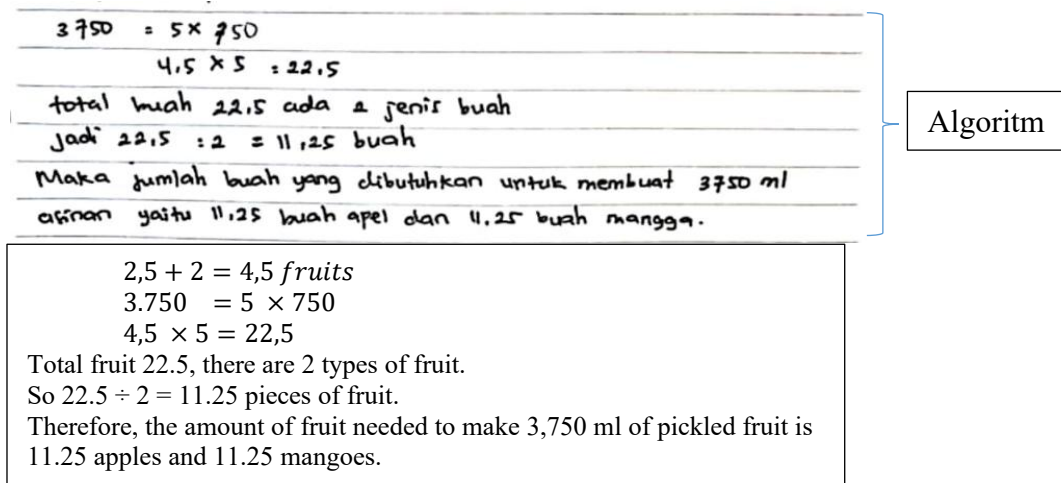


Figure 12. S3 Algorithm Process

The S3 answer was further reinforced by the following interview:

P : "In your opinion, what information is important in this question?"

S3 : "The recipe for 750 ml of pickles requires 2.5 apples and 2 mangoes, and then the question asks how many mangoes and apples are needed for 3750 ml."

P : "Then how did you solve the problem?"

S3 : "3750 ml is a multiple of 5 from 750 ml, so for the fruit, I added 2 plus 2.5, then I multiplied by 5 because the recipe is 5 times, and the result is 22.5. Since there are two types of fruit, I divided by 2, so 22.5 divided by 2 gives 11.5 apples and 11.5 mangoes."

Based on written answers and interview results, subject S3 demonstrated initial ability in problem solving by identifying known and unknown information, as shown in Figure 9. Furthermore, in Figure 10, subject S3 was able to recognize multiples, namely that 3750 ml is a multiple of 750 ml. However, at the simplification stage as shown in Figure 11, subject S3 did not distinguish between the number of apples and mangoes but combined them into the total number of fruits. This error in mathematical modeling affected the final result, as shown in Figure 12, resulting in an inaccurate solution.

In solving PISA questions with the same content, differences in computational thinking processes are clearly visible at each stage of the indicators. At the decomposition stage, students with high numeracy (S1) systematically record known information and questions asked and find the relationship between 750 ml and 3750 ml as a multiple relationship, namely 5 times. In contrast, S2 only wrote down some of the information without explaining the relationship between the data, while S3 preferred to copy the numbers from the question without breaking down the structure of the problem. The result shows that students with high numeracy skills can solve problems by understanding the concept, while students with low numeracy skills do not yet fully understand the structure of the problem.

In the pattern recognition indicator, S1 recognized the pattern of comparison between volume and number of fruits, namely 3750 ml is equal to 5 times 750 ml, and then connected it with a ratio of 2.5 to 2 to create a mathematical model. S2 realized the multiplicative relationship but was still inaccurate in applying the ratio in the next stage. Meanwhile, S3 failed to clearly recognize the comparison pattern, resulting in a problem-solving approach

that relied on trial and error. These differences show that the ability to recognize patterns is an important factor in designing the right strategy.

In the abstraction indicator, S1 can transform the context of the story into a system of linear equations with two variables that formally represent the relationship between the fruits. S2 creates a mathematical model, but it can't yet explain all the connections between variables in a consistent way. S3 does not create a formal model and directly performs calculations without a clear mathematical representation. The results of this study show that students' abstract thinking abilities are highly dependent on their level of ability to understand numbers.

In the algorithm indicator, S1 arranges the steps for solving the problem in a logical sequence, from the modeling process to the final calculation results. S2 creates a plan for solving the problem, but there are still inconsistencies in the substitution and elimination processes. S3 performs calculations directly without following a structured sequence. This experiment shows that the quality of the algorithm is related to the level of understanding of the concept.

Based on the results of the above study discussing the computational thinking abilities of eighth-grade students at SMPIT Al-Falaah Simo in solving PISA questions, it can be concluded that students with high numeracy skills meet all CT indicators and demonstrate systematic integration between indicators in the modeling and problem-solving process. This finding reinforces the research by [Shafa et al. \(2023\)](#) and [Helsa et al. \(2023\)](#), which states that students with high abilities are able to develop structured and consistent problem-solving strategies for contextual problems.

On the other hand, students in the moderate numeracy category only partially display and integrate the CT indicators. The main obstacle lies in the abstraction stage, which causes mathematical representations to be suboptimally formed. This condition is in line with the findings of [Hartawan et al. \(2024\)](#) that abstraction is the most challenging indicator for students in the intermediate category. It is also in line with the findings of [Aisy & Hakim \(2023\)](#), who found that students in the moderate category have partial and less profound computational thinking skills compared to students with high numeracy skills.

Meanwhile, students with low numeracy show fragmentation in their computational thinking process, especially at the abstraction and algorithm design stages. This shows that numeracy not only affects the final result but also the quality of the thinking structure used in solving PISA problems. This is in line with the findings of [Mubarokah et al. \(2021\)](#), students with low numeracy skills can only meet some indicators in computational thinking. They mainly experience difficulties in the abstraction and mathematical modeling stages, which make their solution strategies and calculation results less than optimal. The findings of [Amalia et al. \(2025\)](#) reinforce that students with low computational thinking skills only meet certain indicators without being able to achieve the required level of abstraction. Thus, their problem-solving strategies and calculation results are less than optimal.

4. Conclusion

The analysis and interview results show that students' ability to think computationally when answering PISA quantity questions is affected by their numeracy skills. Students with strong numeracy skills can effectively demonstrate all the computational thinking indicators, like breaking. Students with high numeracy skills are able to fulfill all computational thinking indicators, such as decomposition, pattern recognition, abstraction, and algorithms, systematically and accurately. Students with moderate numeracy skills meet the indicators but still have limitations in solving problems. Meanwhile, students with low numeracy skills

are not yet able to fully meet the computational thinking indicators. These findings show that the higher the students' numeracy skills, the more optimal the computational thinking process demonstrated in solving PISA quantity content questions.

This study helps teachers pay more attention to the differences between students' numeracy abilities and their thinking characteristics so that teachers can create better learning tools and strategies. Further research is recommended to explore PISA questions on various other mathematical content, as well as to examine other thinking skills beyond computational thinking to gain a more comprehensive understanding.

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