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Computational Thinking Skills from the perspective of students' self-confidence in mathematics learning

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Abstract

This research aimed to analyze computational thinking skills from the perspective of students' self-confidence in mathematics learning, employing a qualitative approach and a case study method. The subjects of this research consisted of thirty-five students from tenth grade, selected based on self-confidence—categorized as high, moderate, and low. Data collection techniques included a computational thinking skills test focused on systems of linear equations in two variables, a self-confidence questionnaire, and interviews. The findings reveal that students with high self-confidence demonstrated the ability to meet all indicators of computational thinking skills. In contrast, students with moderate self-confidence could only fulfill two indicators—decomposition and algorithmic thinking—indicating that they struggled with pattern recognition and abstraction. Meanwhile, students with low self-confidence exhibited limited computational thinking skills, with some meeting only the decomposition indicator and others failing to meet any expected indicators.

Keywords

Computational thinking skills, mathematics learning, self-confidence

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Introduction

Computational thinking is the ability to solve problems systematically and logically, which supports students' understanding of mathematical concepts (Supiarmo et al., 2022). This skill encompasses several core indicators, including decomposition, pattern recognition, abstraction, and algorithmic thinking (Wang, 2017). Mastery of computational thinking is essential for students, as it contributes significantly to developing higher order thinking skills (Hauda & Mulyono, 2024). However, computational thinking skills among students in Indonesia remain relatively low. Previous studies have revealed that approximately 50% of students lack computational thinking skills, failing to meet indicators such as decomposition, pattern recognition, algorithms, and debugging (Jamna et al., 2022). This deficiency is further reflected in the 2022 PISA results, which indicate that Indonesian students' mathematical literacy remains below the OECD average despite a slight improvement in ranking compared to 2018.

The 2022 PISA results revealed that Indonesian students scored an average of 366 in mathematics, reflecting a 13-point decline compared to 2018. Moreover, only 18% of students reached Level 2, with almost none achieving Levels 5 or 6 (OECD, 2023). Proficiency at Levels 4, 5, and 6 is categorized as high order thinking and is closely related to computational thinking skills (Haniifah & Nugraheni, 2024). Additional findings indicate that when working on PISA questions related to the "change and relationship" content area, students were generally only able to reach the pattern recognition stage and struggled to advance to abstraction or algorithmic thinking (Supiarmo et al., 2021). These results suggest that students face difficulties when tackling high-level mathematical problems. Such challenges highlight that computational thinking requires more than just conceptual understanding—it also depends on students' confidence in making decisions during problem-solving (Rahmasary et al., 2024). Furthermore, the effective domain, which includes attitudes and motivation, influences learning outcomes. Among these affective factors, self-confidence plays a particularly significant role (Maulidya & Nugraheni, 2021).

Self-confidence is a fundamental aspect of an individual's personality. It reflects a belief in one's abilities. It contributes to reduced anxiety in acting, a sense of freedom in pursuing interests, and a willingness to take responsibility for one's decisions (Andayani & Amir, 2019). The key indicators of self-confidence include trust in one's capabilities, the ability to make independent decisions, a positive self-image, and the courage to act without feelings of shame. In the context of learning, students' self-confidence plays a vital role in determining effective strategies for problem-solving (Febriani & Rahaju, 2024). Students with high self-confidence tend to have greater trust in their understanding of concepts, are more willing to experiment with different approaches, and are better able to evaluate their results. The higher a student's self-confidence, the easier it becomes for them to solve mathematical problems. Conversely, students with low self-confidence often find problem-solving more challenging (Putri et al., 2023).

A comparable situation was observed during the preliminary research phase, encompassing field observations, interviews with teachers and students, and a review of prior studies. The findings revealed that students faced considerable challenges in interpreting word problems, isolating critical information, and translating it into appropriate mathematical models. Furthermore, they appeared unable to formulate structured problem-solving steps or confidently select the most suitable methods. An interview with a mathematics teacher highlighted that many students struggle not only with solving contextual word problems but also with performing calculations and developing effective problem-solving strategies (Sumandya et al., 2022). Similarly, student interviews revealed confusion and difficulty comprehending problem statements, constructing mathematical representations, and choosing appropriate solutions.

These challenges are reinforced by prior research indicating that most students can only fulfill the decomposition stage of computational thinking yet lack the independence required to generate solutions at early stages. Students categorized as high performers could meet all computational thinking indicators, while moderate level students had trouble, particularly with the generalization component. Meanwhile, students in the low-performing group failed to meet any of the indicators and expressed significant difficulty when attempting higher-order thinking skills (HOTS) tasks (Rahmasary, 2024; Kamil et al., 2021). These conditions underscore further research's need to identify the underlying factors contributing to students' difficulties tackling advanced-level mathematical problems.

This research is important because computational thinking significantly develops students' higher order thinking skills (Suhendar & Rosita, 2024; Zaharin et al., 2018). However, existing studies show students' computational thinking skills are still relatively low, particularly in abstraction and algorithmic reasoning. Although self-confidence plays a crucial role in assisting students in effectively solving problems (Fitayanti et al., 2022), its correlation with computational thinking remains largely unexplored. What differentiates this research is its focus on analyzing the relationship between self-confidence and computational thinking at the senior high school level, specifically within the topic of systems of linear equations in two variables. Previous studies have focused on junior high school students and different mathematical topics, such as three-dimensional geometric shapes (Nurhayati, 2024).

Literature Review

In 1980, Seymour Papert introduced the term "computational thinking" and proposed that computers could enhance cognitive processes and reshape how knowledge is accessed (Papert, 1980). He further argued that all children should have access to computers as tools to support their learning and enable them to express their ideas (Papert, 1996). Computational thinking can be integrated into the school curriculum, allowing educators to select appropriate models or instructional strategies to teach these skills to students effectively. Since its introduction, computational thinking has gained growing interest among educators and researchers. It is now recognized as a critical competency that equips students with foundational skills for learning science, mathematics, and technology (Weintrop et al., 2014). Experts agree that embedding computational thinking into classroom instruction can transform how subjects—particularly mathematics—are taught and understood (Wilkerson-Jerde, 2014). There are three key impacts of incorporating computational thinking into mathematics education: fostering a reciprocal relationship between mathematics and computational thinking, creating more accessible learning environments for both teachers and students and modernizing math classrooms through the integration of up-to-date professional practices that reflect advances in the digital age (Weintrop et al., 2016).

Computational thinking is increasingly recognized as a core competency for the 21st century, and thus, educators are strongly encouraged to uphold and embody its foundational principles. Presenting students with meaningful and contextually relevant insights into computational thinking makes them more likely to develop a genuine interest in computer science and become inclined to incorporate computational principles into their future endeavors and daily lives (Juškevičiene & Dagiene, 2018). Far from being an exclusive domain of computer scientists, computational thinking represents a fundamental analytical skill set essential for all individuals. In an era marked by accelerating digital transformation, educators are entrusted with the critical responsibility of equipping students for future demands. Bringing computational thinking into classroom activities, teaching methods, and the overall curriculum helps students learn important modern skills and dramatically improves their learning results and interest in different subjects.

To achieve this, everyone involved in education needs to have a clear understanding of the basic ideas behind computational thinking, which include four main parts: decomposition, pattern recognition, abstraction, and algorithm thinking (Angeli et al., 2016; Boom et al., 2022; Wing, 2017). While computational thinking is often associated with computer programming, applying its core components does not always require computer use. Embracing diverse approaches to computational thinking helps build students' confidence in their ability to think computationally, thereby better preparing them to develop and apply these skills consistently. In complex problem-solving, computational thinking involves several essential elements for students to acquire. These include a solid understanding of mathematical concepts, strong general reasoning skills, knowledge of heuristic strategies, self-belief, and personal attributes such as confidence, perseverance, and self-discipline. Equally important is the ability to clearly and effectively communicate their solutions (Stacey, 2006).

Self-confidence in mathematics refers to a learner's belief in understanding and solving mathematical problems (Bendol & Dalayap Jr, 2025). This psychological factor is widely recognized as a critical determinant of success in mathematics education. Students who believe in their capabilities are more likely to approach mathematical tasks with persistence, resilience, and a positive attitude. This confidence shapes their emotional responses—such as anxiety or enthusiasm—and their cognitive strategies and overall behavior during the learning process. A student with strong mathematical self-confidence is more willing to take on challenges, make sense of abstract concepts, and engage actively in classroom activities. On the other hand, a lack of self-confidence can lead to avoidance, disengagement, or fear of making mistakes, all of which hinder progress (Safitri et al., 2022). Therefore, fostering self-confidence is essential for helping students develop a more profound understanding of mathematics and promoting long-term academic achievement (Sukendra et al., 2024).

Methodology

This research adopted a qualitative approach using a case study method to analyze students' computational thinking skills and self-confidence levels. The research participants consisted of thirty-five tenth-grade students from a high school, selected based on varying levels of self-confidence—categorized as high, moderate, and low. The selection of participants was conducted using a random sampling method. This approach assumed that all tenth-grade students were enrolled in classes that exhibited similar distributions of self-confidence levels. Therefore, it was presumed that no significant differences in self-confidence existed across the various class groups, ensuring that the random sample would fairly represent the overall students. Data were collected through computational thinking tests based on the Systems of Linear Equations in Two Variables, semi-structured interviews, and a self-confidence questionnaire.

The instruments used in the research included a test designed to assess computational thinking skills specifically within the topic, an interview guide to explore students' thought processes, and a self-confidence questionnaire aligned with specific scoring criteria outlined in Table 1 below.

Table 1. *Self-confidence criteria*

Criteria	Scores
High	24-64
Moderate	65-90
Low	91-100

(Khasmawati et al., 2022)

Data analysis included data reduction (presenting the results of self-confidence data processing after students completed computational thinking skills questions descriptively and systematically), data presentation (showing the results of computational thinking skills achievements based on students' self-confidence levels in the form of a complete table), and drawing conclusions (writing systematic, complete, and orderly conclusions from the research so that readers can understand the relationship between self-confidence levels and computational thinking skills).

Findings

Research on tenth-grade students produced data on their self-confidence levels. The results of the data collection are presented in Table 2 below.

Table 2. *Results of the self-confidence questionnaire*

Criteria	Scores	Number of students
High	24-64	7
Moderate	65-90	20
Low	91-100	8

Based on the results of the self-confidence questionnaire, most students fall into the moderate level, with 20 students scoring between 65 and 79. This indicates that they have a sufficient level of self-confidence in learning. Seven students fall into the high level, with scores ranging from 80 to 96, showing that only a few possess strong self-confidence. Meanwhile, eight students are at the low level, with scores between 24 and 64, indicating that some still struggle to build self-confidence when facing learning challenges. Based on the self-confidence questionnaire data analysis, two students from each level, high, moderate, and low—were selected to be interviewed to gain profound insights. Excerpts from the interview results are presented below.

Interviewed findings: High self-confidence level

The first student (S1) and the fourth student (S4) demonstrated high self-confidence, as reflected in their responses during the interview. They were interviewed in a calm and comfortable condition.

> "If there is a difficult question, do you usually try to solve it on your own first, or do you
> "Do you consider yourself good at mathematics?" [teacher]
>
> "I understand mathematical concepts quite well. Besides that, I'm also good at calculations." [S1]
>
> "If you're given multiple methods to solve a problem, do you prefer to choose your method or follow your friends?" [P]
>
> "I prefer to choose my method." [S4]
>
> "When doing class assignments or homework, do you usually wait to be told, or do you complete them independently?" [P]
>
> "I do it on my own, ma'am, because I see it as my responsibility." [S1]
>
> "In your opinion, what are your strengths in mathematics?" [P]
>
> "I can quickly grasp newly taught material." [S4]
>
> "Have you ever felt proud of yourself after successfully solving a math problem?'
> Could you tell me how?" [P]
>
> "Often, especially when I get the chance to explain how I solved the problem." [S1]
>
> "Are you confident enough to come to the front of the class to explain and solve a problem?" [P]
>
> "Yes, I am. It's been a habit since elementary school." [S4]

> "Do you feel comfortable asking the teacher when there's a topic or problem you don't understand?" [P]
>
> "Yes, I do. What gives me the courage to ask is my curiosity." [S1]

This excerpt illustrates several key indicators of high self-confidence, such as initiative, independence in learning, a positive self-perception of ability, and the courage to communicate and participate actively in classroom activities. They demonstrate confidence in understanding mathematical content and take pride in helping others understand problem-solving processes.

Interviewed findings: Moderate self-confidence level

The second student (S2) and the fifth student (S5) were identified as having a moderate level of self-confidence based on the analysis of the self-confidence questionnaire and the follow-up interviews. The responses provided by students S2 and S5 reflect strengths and areas of hesitation related to self-confidence in learning mathematics.

> "Do you consider yourself good at math?" [P]
>
> "I think I'm good at or capable of doing math, at least in the context of school." [S2]
>
> "If you are given several methods to solve a problem, do you prefer to choose your method or follow your friends?" [P]
>
> "I would choose my method." [S5]
>
> "When doing assignments or homework, do you usually wait to be told, or do you complete them independently?" [P]
>
> "I usually wait to be told first before doing my homework." [S2]
>
> "Have you ever felt proud of yourself for solving a math problem? Can you explain how?" [P]
>
> "Yes, I have. For example, when I struggled with a problem for a long time and couldn't find the answer, then suddenly an idea appeared, and I was finally able to solve it. I felt proud after going through the effort." [S5]
>
> "Are you confident enough to come to the front of the class to explain and solve a problem?" [P]
>
> "Yes, I'm ready and willing to do that." [S2]

> "Do you feel confident asking the teacher when you don't understand the material or a problem?" [P]
>
> "I don't feel very confident about asking the teacher because I get nervous and feel embarrassed." [S5]

The responses from students S2 and S5 suggest a balanced, though not fully developed, level of self-confidence. On the one hand, the student demonstrates initiative and perseverance when solving complex problems and takes pride in moments of academic success. They could also make independent decisions, as seen in using personal problem-solving methods rather than relying on peers. Moreover, they have a positive academic self-concept, viewing themselves as competent in mathematics. On the other hand, there are notable limitations in self-directed behavior. They admit to waiting for instructions before beginning assignments, indicating dependency on external prompts. Additionally, while they are confident in presenting solutions in front of the class, they lack confidence in verbal interactions with authority figures, such as asking the teacher questions—primarily due to nervousness and embarrassment.

These findings support classifying the students as having a moderate level of self-confidence. The student shows potential for strong self-efficacy but has not yet fully developed the emotional resilience or independence associated with high self-confidence. Continued support and exposure to opportunities that encourage autonomy and safe communication with teachers could further enhance the student's confidence in mathematics.

Interviewed findings: Low self-confidence level

Based on the interview summary, students coded S3 and S6 demonstrated low levels of self-confidence in learning mathematics. While student S3 showed some ability to solve problems independently, student S6 required assistance to complete similar tasks, indicating a lack of confidence in problem-solving without external support. Both students expressed self-doubt regarding their mathematical abilities, stating they did not consider themselves proficient at mathematics.

Regarding decision-making autonomy, student S3 could make independent choices without waiting for instructions, whereas student S6 tended to be passive and waited to be directed. Neither student exhibited a positive self-perception, as both believed they were not competent enough in mathematics. Furthermore, both lacked the courage to act without fear or shame, particularly when facing classroom interactions that required public speaking or asking for help. They reported embarrassment and fear when asked to explain their reasoning in front of others and hesitated to ask questions when facing difficulties—further highlighting their lack of confidence.

General analysis of student self-confidence levels

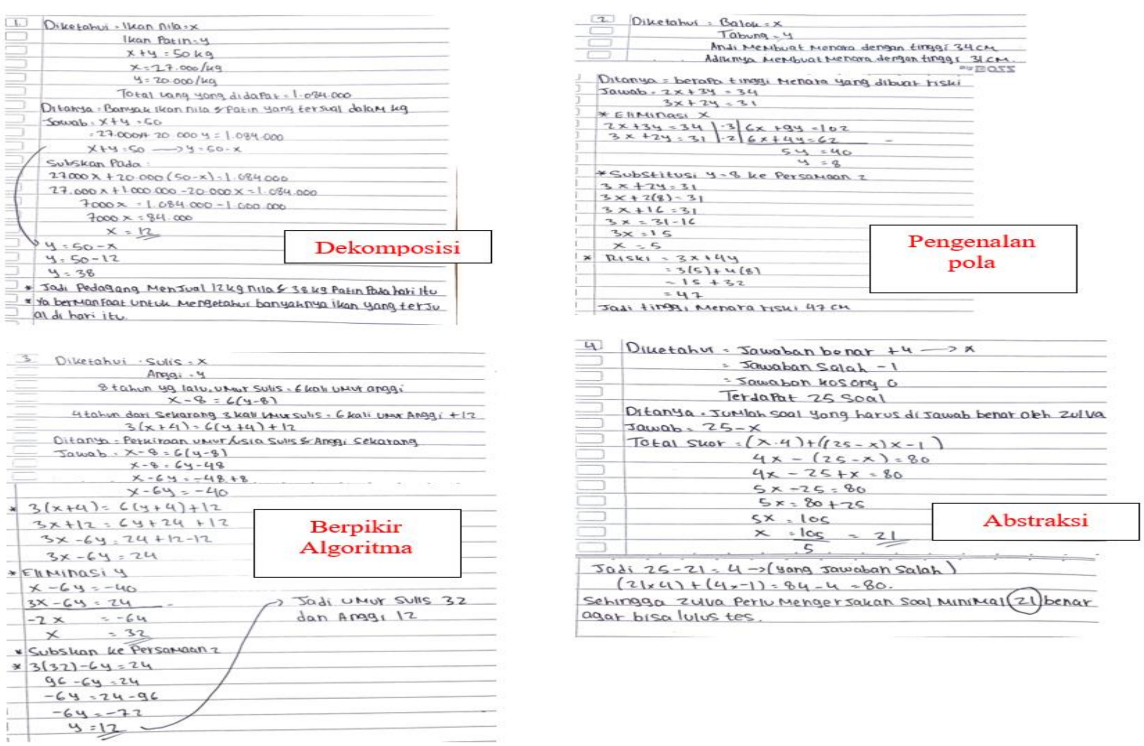
The overall results of the interviews revealed a spectrum of self-confidence among students regarding mathematics:

a. Students with high self-confidence demonstrated strength in all identified indicators. They believed in their capabilities, took initiative, made independent decisions, maintained a positive self-concept, and were unafraid to ask questions or participate in class discussions.
b. Students with moderate self-confidence showed some key traits, such as belief in their skills and willingness to make independent decisions. However, they still struggled to express themselves confidently in public, particularly when asking teachers questions or presenting in class.
c. Students with low self-confidence fell short across multiple dimensions. They doubted their abilities, depended on external guidance, lacked a strong sense of self-efficacy, and avoided active participation due to fear or embarrassment. This level requires significant support to build confidence and encourage active engagement in mathematics learning.

Computational thinking skills of students with high self-confidence levels

Students S1 and S4 have high self-confidence and can meet all indicators of computational thinking skills.

Figure 1. *Results of students' answers with high self-confidence levels [in Indonesian Language]*



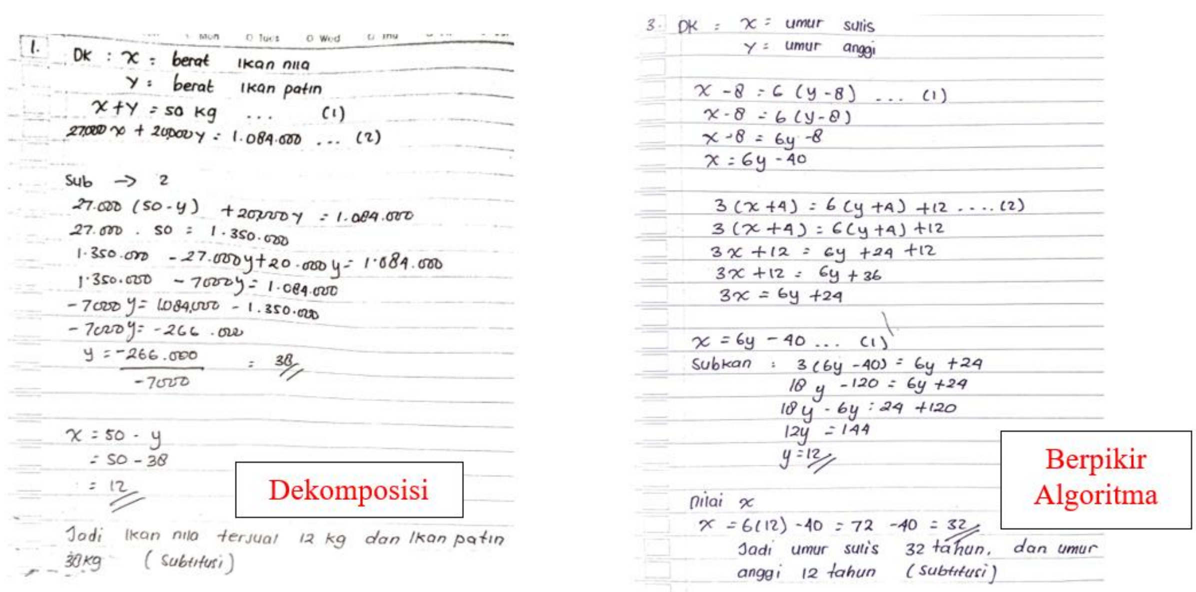
S1 demonstrated the ability to meet all indicators of computational thinking. They can break down problems into smaller parts (decomposition), recognize similarities and differences in patterns (pattern recognition), arrange logical steps to solve the problem (algorithmic thinking), and draw conclusions by eliminating irrelevant elements (abstraction). Besides that, S4 also shows the ability to meet all indicators of computational thinking. They can divide complex problems into smaller components, identify patterns, construct step-by-step procedures, and simplify the problem by abstracting unnecessary information**.**

The interview results from S1 and S4 indicated that S1 had high self-confidence and met all indicators of computational thinking skills. He was able to identify important information from the problem and correctly map variables, such as symbolizing the type of fish as a variable and recording the weight and price data of the fish. The student explained the initial steps in the decomposition indicator by sorting out important information and forming equations. He also demonstrated the ability to recognize patterns, such as identifying the tower structure built by Andi and his brother to construct a system of equations. In the abstraction indicator, the student filtered out irrelevant information, for example, by stating that the blank answer information was unimportant because it did not affect the results. Finally, through algorithmic thinking, he explained the systematic steps in solving the system of linear equations in two variables, starting with forming equations, eliminating, substituting, and arriving at the final solution.

Computational thinking skills of students with a moderate self-confidence level

Students S2 and S5 have a moderate level of self-confidence and can only fulfill two indicators of computational thinking skills: decomposition and algorithmic thinking.

Figure 2. *Results of students' answers with moderate self-confidence level [in Indonesian Language]*



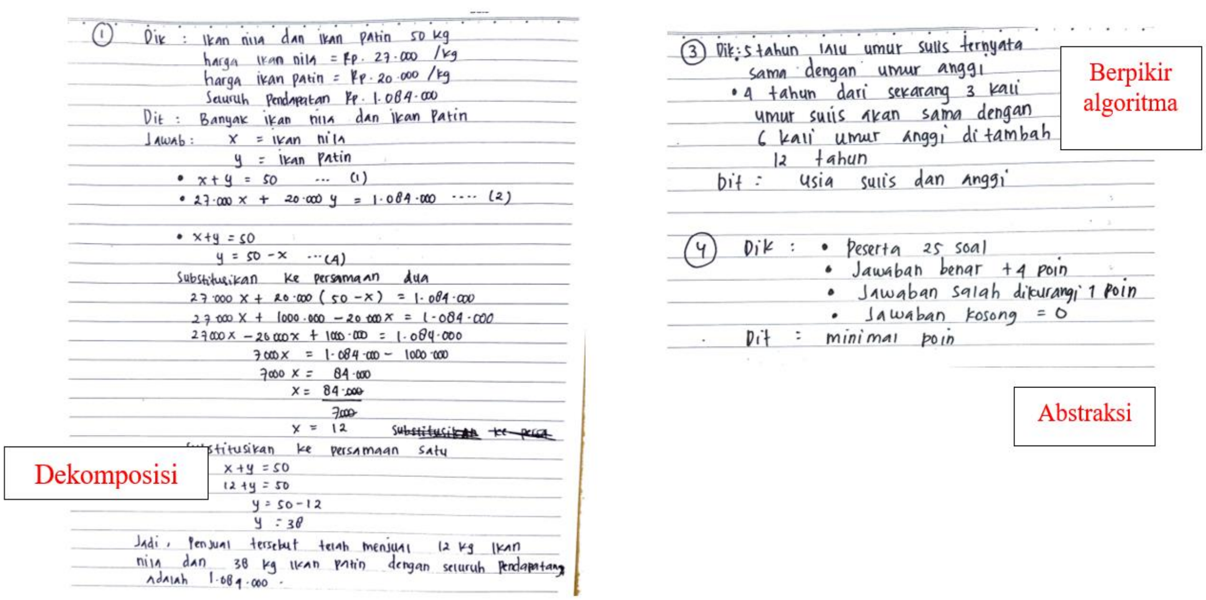
Based on the results of students' answers, students S5 with a moderate level of self-confidence can only fulfill two indicators of computational thinking skill: decomposition and algorithmic thinking. Students S2 and S5 do not meet the requirements for pattern recognition and abstraction indicators. In the decomposition indicator, S5 describes important information from the problem, such as the type of fish, total weight, unit price, and total price. He broke the problem into two linear equations and chose the substitution method to solve it, which shows excellent decomposition ability. In the algorithmic thinking indicator, S5 carefully organizes the steps to solve the system of linear equations by making two equations, using an elimination method, and then applying substitution to get the final answer. This activity shows algorithmic thinking ability because students can organize the solution procedure logically and efficiently.

Based on the interview results, students fulfilled two indicators of computational thinking skills: decomposition and algorithmic thinking. This ability is evident in how the student identified important information in the problem, such as the total weight of the fish, the price per kilogram for each type of fish, and the total sales. The student also broke down the information into variables *x* and *y*, formulated two linear equations, and solved them using the substitution method. The students responded that they did not understand questions 2 and 4 because they lacked sufficient comprehension of them. Therefore, their performance could not be assessed for the pattern recognition and abstraction indicators.

The computational thinking skills of students with low self-confidence level

Students S3 and S6 have low self-confidence levels. They can only fulfill one indicator of computational thinking skill—decomposition in the case of student S3—while student S6 does not fulfill any of the computational thinking indicators.

Figure 3. *Results of students' answers with low self-confidence levels [in Indonesian Language]*



Based on student S3's work results, this student only fulfilled one computational thinking skill indicator, decomposition. This is evident from their ability to break down the information in the problem into important parts such as the price of fish, the weight of the fish, and the total money from sales. The indicators of algorithmic thinking and abstraction were not fulfilled, as the student only copied the information from the question without showing any systematic steps in solving the problem or simplifying it into mathematical sentences. The pattern recognition indicator was also not fulfilled because the student did not answer the questions that assessed this ability. The student still requires guidance to develop computational thinking skills comprehensively.

Based on the interview results, student S3 also only fulfilled one indicator of computational thinking: decomposition, as seen in their ability to identify important information in the question, such as the price of fish per kilogram and the amount of money earned. The students did not demonstrate abstraction or algorithmic thinking skills, as they only wrote down the known and asked information without processing or simplifying it into an equation. Furthermore, the students could not meet the pattern recognition indicator because they did not answer the relevant question and stated that they felt confused from the beginning when reading it.

The research findings show a relationship between students' levels of self-confidence and their computational thinking skills. Students with high self-confidence meet all the indicators of computational thinking. On the other hand, students with moderate self-confidence only met two indicators—decomposition and algorithmic thinking—while students with low self-confidence showed the fulfillment of only one indicator and, in some cases, did not meet any indicators. Based on this description, the following table 3 presents the students' achievements in computational thinking skills:

Table 3. *Computational thinking skills achievement*

Subjects	Self-confidence	Computational thinking skill indicators			
		Decomposition	Pattern recognition	Algorithmic thinking	Abstraction
S1	High	✓	✓	✓	✓
S4		✓	✓	✓	✓
S2	Moderate	✓	x	✓	x
S5		✓	x	✓	x
S3	Low	✓	x	x	x
S6		x	x	x	x

Discussion

Students with high self-confidence tend to approach mathematical problem-solving independently and with initiative. They can work through problems independently without relying on direct instructions from teachers or peers. These students also exhibit strong decision-making skills and a positive self-image, which are reflected in their willingness to ask questions and present explanations in front of the class. Their ability to communicate ideas confidently shows that they do not experience significant hesitation, fear, or embarrassment when engaging in academic activities—an indication of healthy self-assurance.

This elevated self-confidence has a positive correlation with their computational thinking skills. Computational thinking comprises four fundamental components: decomposition, pattern recognition, algorithmic thinking, and abstraction. Students with high self-confidence are often able to break down complex mathematical problems into smaller, more manageable parts (decomposition), identify recurring structures and relationships (pattern recognition), formulate step-by-step procedures or logical sequences to solve issues (algorithmic thinking) and generalize or model the essential aspects of a problem while filtering out irrelevant details (abstraction).

Research supports the idea that students with higher self-confidence are more likely to achieve better academic outcomes because they are intrinsically motivated. This internal drive encourages them to persevere through challenges, explore alternative strategies, and maintain focus in problem-solving situations (Irman et al., 2022; Isyana et al., 2024; Maulidya & Nugraheni, 2021). For instance, these students can identify the key elements of mathematical problems related to systems of linear equations in two variables, represent unknowns using symbols, and discard unnecessary information. These actions show mastery of abstraction and decomposition. Furthermore, they can detect patterns within the problem and create a logical sequence of steps to arrive at a solution, demonstrating strong pattern recognition and algorithmic thinking skills. In summary, high self-confidence in students enhances their motivation and communication skills and significantly supports their ability to apply computational thinking processes effectively in mathematics learning.

Students with a moderate level of self-confidence demonstrated only two dimensions of computational thinking: decomposition and algorithmic reasoning. These individuals could identify key information and formulate logical steps for problem-solving tasks. However, they exhibited limited proficiency in pattern recognition and abstraction—skills essential for addressing more complex and dynamic problems. This deficiency may be attributed to a lack of comprehensive self-confidence, particularly in contexts that demand autonomous initiative, such as problem-solving without direct instruction or independently posing inquiries. Such constraints appear to inhibit their ability to explore and implement more advanced and nuanced strategies for resolving non-routine problems (Evans et al., 2021).

In contrast, students with low self-confidence demonstrated significantly weaker performance in computational thinking. For instance, one participant exhibited only the ability to decompose a problem, which is —evident in their success in isolating relevant information, such as the price and weight of fish, from the problem statement. Other students within this group failed to meet any of the assessed indicators. They struggled to extract meaningful information, identify patterns, construct a logical sequence of steps, or engage in abstraction by eliminating irrelevant components. These findings highlight how self-confidence may play an important role in how well students can effectively use computational thinking skills (Lestari & Roesdiana, 2023).

Conclusion and Implications

The findings suggest that the higher the students' self-confidence, the better their computational thinking skills. The higher their self-confidence, the more proficient they tend to be in applying computational thinking processes. To strengthen the generalizability of these conclusions, future research should include a broader and more diverse sample of participants. Additionally, computational thinking skills may also be influenced by other variables, such as learning styles, levels of interest in learning, or the instructional strategies employed.

The relationship between self-confidence and computational thinking bears serious consequences for mathematics education. It influences how students receive and process mathematical instruction, their attentiveness during lessons, their ability to comprehend the teacher's explanations, and the agility of their cognitive processing when confronting high-order problems. Teachers are encouraged to consider students' confidence levels in designing pedagogical strategies that align with the material's complexity and learners' cognitive readiness. Higher order thinking skills serve as the foundation for advancing computational thinking. Students should be consistently exposed to non-routine problems to foster confidence and skill development. Regular engagement with such problems promotes the cultivation of computational thinking while simultaneously reinforcing self-confidence.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest.

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