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Analytic Reasoning Process of High School Students in Solving Quadratic Equation Problems Based on Computational Thinking Skills

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ABSTRACT

Analytical reasoning and computational thinking are two essential skills in mathematics education, especially in solving complex problems such as quadratic equations. This study aims to describe the analytical reasoning process of high school students in solving quadratic equation problems based on computational thinking skills. This study employs a descriptive qualitative approach, with data collected through tests and interviews with 30 students at a high school in Jember, categorized into three levels of computational thinking skill: high (S1), moderate (S2), and low (S3). One subject from each category was selected as a representative for in-depth analysis based on analytical reasoning indicators adapted from Fisher (2011), namely: problem identification, relationship analysis, strategy formulation, and solution evaluation and justification. The research results indicate that S1 demonstrates coherent and flexible analytic reasoning, characterized by precise problem identification, accurate model formation, adaptive strategy use, and implicit verification of results. S2 showed generally systematic reasoning, especially in translating contextual information into algebraic models and performing procedural operations. However, their analytic reasoning tended to rely on fixed procedures, with limited evaluative judgment or strategic adaptation. In contrast, S3 exhibited fragmented reasoning, difficulties in constructing symbolic models, and minimal solution validation, often caused by challenges in decomposing information and analyzing relational structures. These findings provide insights that can help teachers design more adaptive and effective learning strategies to encourage higher-order thinking skills in students.

Keywords: *Analytical reasoning, Computational thinking, Quadratic equations, Secondary education*

Proses Penalaran Analitik Siswa SMA dalam Menyelesaikan Masalah Persamaan Kuadrat Ditinjau dari Keterampilan Berpikir Komputasi

ABSTRAK

Penalaran analitik dan berpikir komputasi merupakan dua keterampilan penting dalam pendidikan matematika, terutama dalam menyelesaikan masalah kompleks seperti persamaan kuadrat. Penelitian ini bertujuan untuk mendeskripsikan proses penalaran analitik siswa SMA dalam menyelesaikan masalah persamaan kuadrat berdasarkan keterampilan berpikir komputasi. Penelitian ini menggunakan pendekatan deskriptif kualitatif, dengan data dikumpulkan melalui tes dan wawancara terhadap 30 siswa di sebuah SMA di Jember, yang dikategorikan ke dalam tiga tingkat keterampilan berpikir komputasi: tinggi (S1), sedang (S2), dan rendah (S3). Satu subjek dari setiap kategori dipilih sebagai perwakilan untuk dianalisis secara mendalam berdasarkan indikator penalaran analitik yang diadaptasi dari Fisher (2011), yaitu: identifikasi masalah, analisis hubungan, perumusan strategi, serta evaluasi dan justifikasi solusi. Hasil penelitian menunjukkan bahwa S1 memiliki penalaran analitik yang koheren dan fleksibel, ditandai oleh identifikasi masalah yang tepat, pembentukan model yang akurat, penggunaan strategi yang adaptif, serta verifikasi hasil secara implisit. S2 memperlihatkan penalaran yang umumnya sistematis, terutama dalam mengubah informasi kontekstual menjadi model aljabar dan menjalankan langkah-langkah prosedural. Namun, penalaran analitik mereka cenderung bergantung pada prosedur tetap, dengan evaluasi yang terbatas dan minim adaptasi strategi. Sebaliknya, S3 menunjukkan penalaran yang terfragmentasi, kesulitan membangun model simbolik, dan minimnya validasi solusi, yang banyak disebabkan oleh tantangan dalam mendekomposisi informasi dan menganalisis struktur hubungan. Temuan ini memberikan wawasan bagi guru untuk merancang strategi pembelajaran yang lebih adaptif dan efektif guna mendorong keterampilan berpikir tingkat tinggi pada siswa.

Kata Kunci: *Penalaran analitik, Berpikir komputasi, Persamaan kuadrat, Pendidikan menengah*

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1. Introduction

Analytical reasoning is an essential ability in learning mathematics, as it enables students to analyze problems, recognize patterns, and design solutions logically and systematically. As stated by Qolfathiriyus (2019), analytical reasoning is a thinking ability that analyzes information logically and systematically to draw valid conclusions. This ability is needed in solving complex mathematical problems that require understanding of concepts and appropriate solution strategies, such as quadratic equation. Analytical reasoning helps students break down a problem into manageable parts, identify relevant mathematical principles, and choose the most efficient method for obtaining a solution (Muis, 2017). In particular, solving quadratic equations often requires students to move beyond rote memorization and apply logical steps in a structured sequence, such as identifying coefficients, recognizing patterns in the equation, and selecting appropriate methods like factoring, completing the square, or using the quadratic formula (Syarifuddin et al., 2020). Without strong analytical reasoning, students may struggle to interpret the problem correctly or determine which solution path is most suitable, leading to errors and misconceptions. Therefore, strengthening analytical reasoning is crucial for developing deeper mathematical understanding and fostering students' ability to solve problems independently (Widiyasari & Nurlaelah, 2019).

Quadratic equations are part of the material at the high school level which often poses its own challenges for students, because its solution requires understanding of concepts and systematic analytical reasoning skills (Lee, C., & Johnston Wilder, 2017). In addition, various studies show that students still have difficulty in formulating strategies for solving quadratic equations based on the logic of mathematical reasoning (Meryansumayeka et al., 2021). According to Wing (2006), quadratic equation problems not only demand analytical reasoning skills, but also require a structured approach such as computational thinking because they include symbolic representations, graphs, and mathematical solutions that require analytical reasoning-based solution strategies such as factorization, completing the square, and using the quadratic formula. The integration of computational thinking, including decomposition, algorithms, and pattern recognition, has been shown to support mathematical understanding and improve students' analytic reasoning (Weintrop et al., 2016). In addition, computational thinking in mathematics learning can strengthen the skills of analyzing information, problem solving, and foster student confidence (Fauzi, 2023). This finding is reinforced by Ghufron et al. (2023) also found that the integration of computation in learning has a positive impact on students' reasoning and critical thinking skills.

In fact, Indonesian students' higher order thinking skills, including analytic reasoning and systematic thinking, are still remain relatively low. This is based on the Program for International Student Assessment (PISA) 2022 results released by the OECD, the average score of mathematical literacy of Indonesian students is 379, ranked 68th out of 81 countries, far below the OECD average of 472. Similar results were also seen in TIMSS 2019, where Indonesian grade VIII students only scored 397, below the international average of 500 (Lestari & Annizar, 2020). This data results shows weak mastery of essential mathematical thinking skills, including in solving complex problems such as quadratic equations. This condition is a warning for education to review students' analytic reasoning process in terms of computational thinking skills.

Although analytic reasoning and computational thinking are two complementary skills, there are still few studies that examine their relationship explicitly in the context of mathematics learning in Indonesia. In fact, an in-depth understanding of how students use both skills in solving quadratic equation problems can assist teachers in designing more effective and adaptive learning strategies (Ningsih et al., 2021). In addition, this research is becoming increasingly relevant given the importance of equipping students with 21st century skills that include not only conceptual understanding but also systematic analytical reasoning ability, computational thinking ability, and creativity (Fauzi, 2023). Analytical reasoning is a foundational component of these competencies, and its integration into classroom instruction is necessary to prepare students for academic and real-life challenges (Nurrahmawati, 2021). As such, fostering analytical reasoning through meaningful mathematical tasks, including those involving quadratic equations, aligns with broader educational aims and international benchmarks for student achievement. Fitriyah et al. (2023) also noted that few studies have explicitly examined students' analytic reasoning in high school mathematics learning.

Therefore, this study aims to describe and analyze students' analytic reasoning process in solving quadratic equation problems in terms of computational thinking skill. To further enhance students’ problem-solving skills, analytical reasoning should be developed in tandem with computational thinking. While analytical reasoning focuses on logical structure and deductive processes, computational thinking emphasizes decomposition, pattern recognition, algorithm design, and abstraction. These skills complement each other, particularly in mathematical problem-solving, where students must navigate complex procedures, select efficient methods, and adapt their strategies to different problem types. This research is expected to help teachers in designing adaptive and innovative learning strategies and contribute to developing pedagogical interventions to improve the quality of mathematics learning so that it can support and improve the achievement of students' mathematical competencies holistically.

2. Method

This research was conducted at one of the Senior High Schools located in Jember using a descriptive qualitative method. The research instrument used was a test using 5 high school level bebras description questions and 2 quadratic equation description questions that have met the valid category. In addition, the instruments used by researchers were modified indicators of Analytical Reasoning of Fisher (2011) as well as interviews to complete the necessary data. While the subject determination technique used is purposive sampling technique where the researcher determines the sampling tailored to the research objectives. 30 subjects who are class X students, were given a test instrument in the form of 5 free questions with a duration of 15 minutes to measure students' computational thinking skills which were then categorized based on the test result classification guidelines in Table 1.

Table 1. Classification of Computational Thinking Ability Based on Test Results

Range of Values	Classification
66,7 ≤ Value ≤ 100	High
33,4 ≤ Value ≤ 66,6	Medium
0 ≤ Value ≤ 33,3	Low

Source: (Lestari &Annizar, 2020)

Table 2. Analytical Reasoning Indicators, *Adapted from Fisher (2011)*

Indicator	Sub-Indicator	Description
Problem Identification	Identifying key elements in the problem	Students can determine variables, relationships between quantities, and known/unknown information in quadratic equations or functions.
	Distinguishing relevant and irrelevant information	Students can filter needed information to solve quadratic problems without being distracted by unnecessary data.
Relationship Analysis	Connecting problem information with relevant concepts	Students relate quadratic equations with their properties such as roots, vertex, or graph.
	Determining patterns or regularities in the given problem	Students recognize relationships between equation coefficients and graph properties (e.g., the discriminant determines the number of real roots).
Strategy Formulation	Determining the appropriate solving method based on the problem's characteristics	Students choose suitable methods like factoring, completing the square, or using the quadratic formula based on the equation form.
	Developing a systematic and logical problem-solving procedure	Students organize solution steps sequentially from problem identification to interpreting the results.
Evaluation and Solution Justification	Interpreting results based on problem context	Students evaluate if the solution makes sense in context, e.g., discarding negative values when dealing with length or area.
	Verifying the solution via substitution or other methods	Students check their answer by substituting values back into the original equation.

Out of the 30 students, the scores obtained vary so that based on the classification guidelines for computational thinking ability above, the researcher took three subjects representing high, medium, and low computational thinking abilities who were then given a test instrument on quadratic equations to find out the analytic reasoning process of the 3 subjects based on the adapted from Fisher (2011) analytic reasoning indicators in Table 2. After working on the quadratic equation problem, the 3 subjects were interviewed according to the analytic reasoning indicators related to the stages in solving the problem to further clarify the implied stages of the subject's work.

Based on the explanation above, the analysis of the subject's analytic reasoning process uses the adapted from Fisher (2011) analytic reasoning indicators and uses method triangulation to test the validity of the data. Then explained step by step about the subject's analytic reasoning process in solving the quadratic equation test instrument.

3 Results and Discussion

The initial test was given to the research subjects to classify the level of computational thinking ability of each subject. The test instrument given to 30 students was in the form of 5 high school level bebras questions in essay form with a duration of 15 minutes. Based on the classification guidelines of the initial test results in Table 3, the researcher categorized the research subjects into subjects who had high, medium, and low computational thinking abilities.

Table 3. Categories of Computational Thinking Ability Based on Initial Test Results

Range of Values	Frequency	Classification	Codes
66,7 ≤ Value ≤ 100	8 students	High	S1
33,4 ≤ Value ≤ 66,6	16 students	Medium	S2
0 ≤ Value ≤ 33,3	6 students	Low	S3

The data showed that out of 30 students, 8 students had high computational thinking ability, 16 students had medium computational thinking ability, and 6 other students had low computational thinking ability. Then based on the classification guidelines of the initial test results, the researcher chose three subjects representing each category. S1 as the first subject is a student who has high computational ability, S2 as the second subject who has medium computational ability, and S3 as the third subject who has low computational thinking ability. Furthermore, the three subjects were given a test in the form of 2 quadratic equation essay questions and then continued by conducting an interview session to complement the data and clarify the stages of work done by the three subjects based on adapted from Fisher (2011) analytic reasoning indicators.

3.1 The Analytic Reasoning Process of High Computational Skill (S1)

This subsection examines the analytic reasoning process demonstrated by students with high computational skills (S1). It aims to describe how they interpret problems, construct appropriate models, and execute solution strategies systematically and accurately.

Based on the S1's answer (Figure 1) and interview results, S1 begin solving the problem by identifying the important information in the question, namely the area of the rectangle is $240m^2$ and one side is $4cm$ longer than the other. Students demonstrate problem identification skills by recognizing that this problem is related to the concept of the area of a rectangle, namely $L = p \times l$ by writing $240 = p \times l$. Then S1 translated the problem into a mathematical model by defining the width as l and the length as $l + 4$, resulting in the area equation $240 = (l + 4)l$.

Jawablah soal-soal berikut dengan jawaban yang benar disertai tahapan-tahapan penyelesaian! 1. Seorang petani memiliki sebidang tanah berbentuk persegi panjang dengan luas 240 m². Jika panjang tanah tersebut 4 meter lebih panjang dari lebarnya, tentukan panjang dan lebar tanah tersebut!	English Version: **Answer the following questions with the correct solution accompanied by detailed steps of the problem-solving process!** 1. A farmer owns a rectangular plot of land with an area of 240 square meters. If the length of the land is 4 meters longer than its width, determine the dimensions (length and width) of the land!
S1's answer: 1. $240 = p \cdot l$ $= (l+4)l$ $20 \cdot 16 = (l+4)l$ $l = 16 \quad p = 20$	Note: p = is used to denote the length (in meters) l = is used to denote the width (in

Figure 1. Quadratic equation problems 1 and S1's answer

This step demonstrates students' skill to construct mathematical models from contextual situations, which is an important indicator of analytical reasoning (Damayanti et al., 2019). Similar findings were also reported by Nurrahmawati (2021), who emphasized that translating verbal problems into symbolic representations is a crucial early phase of students' reasoning development. Furthermore, the ability to identify relevant information aligns with the characteristics of computational thinking decomposition, where students break down complex situations into manageable components (Yadav et al., 2017).

However, S1 did not solve the quadratic model algebraically by factoring or completing the square, but rather used a numerical approach by trial and error with factor pairs of 240. S1 explained that they tried multiple combinations and identified 20×16 as one of the valid factor pairs. After identifying several possible factor pairs, S1 relates them to $(l + 4)l$ and realizes that 20 and 16 satisfy the relation $(l + 4)l$, so $l = 16$ and $p = 20$ because $p = l + 4$. This solution path demonstrates that S1's reasoning did not rely solely on computational trial and error, but on an ability to evaluate which numerical relationships align logically with the underlying algebraic form of the problem. Building on this, the strength of S1's strategy lies not in the simplicity of the numbers used, but in the flexibility shown in recognizing the underlying mathematical structure. By focusing on the relational form rather than on procedural manipulation of "friendly" numbers, the reasoning applied by S1 remains effective even when the problem involves larger or more complex values (Fisher, 2011). This indicates that S1 engages in structural reasoning, which emphasizes identifying and using the mathematical relationships embedded within a problem rather than relying on surface-level computations (Fauzi, 2023). Such flexibility reflects a higher-order analytical process in which students adapt strategies based on conceptual understanding, rather than following mechanical procedures (Wells, 2018). Furthermore, the ability to generalize relational structures is a key characteristic of analytical reasoning, enabling students to maintain accuracy even when confronted with increased numerical or algebraic complexity (Putri et al., 2022). This type of numerical reasoning aligns with Wati et al (2018), who found that students frequently use intuitive strategies before transitioning to formal algebraic manipulation. Additionally, Damayanti et al (2019) emphasize that such strategic flexibility strengthens students' mathematical resilience, allowing them to persevere even when facing unfamiliar or challenging problem situations.

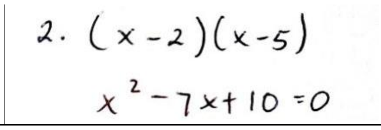
2. Jika akar-akar persamaan kuadrat adalah 2 dan 5, tentukan persamaannya!	English Version: 2. If the roots of a quadratic equation are 2 and 5, determine the equation!
S1's answer: 	

Figure 2. Quadratic equation problems 2 and S1's answer

In question problems 2 (Figure 2), S1 began by identifying the nature of the problem specifically, that the roots of the quadratic equation were already provided. Recognizing this, based on the interview result S1 applied the root-to-equation conversion method, using the standard form $(x - r_1)(x - r_2) = 0$, where r_1 and r_2 are the roots. After determining the general form of the quadratic equation, S1 determines the roots of the equation, namely r_1 is 2 and r_2 is 5. Recognizing that roots r_1 and r_2 correspond to factors $(x - r_1)(x - r_2)$. This shows that S1 has internalized a pattern that can be quickly applied in similar problems (Syarifuddin et al., 2020). This ability to convert roots into an equation also reflects students' structural understanding of algebra, where equations are perceived as interconnected objects rather than isolated procedures (Ghufron, 2023). Substituting the given values, S1 correctly formed the expression $(x - 2)(x - 5) = 0$. For strategy formulation, S1 selected the correct and efficient method for constructing a quadratic equation from given roots, and logically followed through with expansion to derive the standard form. Although the problem was relatively straightforward and did not require the comparison of multiple strategies, the choice of method was both appropriate and executed correctly (Asanre et al., 2024). This indicates a solid grasp of the relationship between roots and factors, which is essential for generalizing algebraic patterns (Putri et al, 2022). This finding is in line with the study by Nabilah & Shodikin (2025), which shows that students' reasoning plays an important role in constructing and generalizing quadratic patterns based on their initial mathematical ability. S1's approach illustrates the ability to apply mathematical principles in reverse, building an equation rather than solving one (Putri et al, 2022). This kind of pattern internalization is known to reduce cognitive load during algebraic tasks (Damayanti, 2019). Furthermore, S1 expanded it to produce the standard quadratic form $x^2 - 7x + 10 = 0$. This shows that the evaluation and justification step were minimal due to the simplicity of the problem, the expansion of the factored form to standard form, serves as implicit verification result (Afandi et al., 2022).

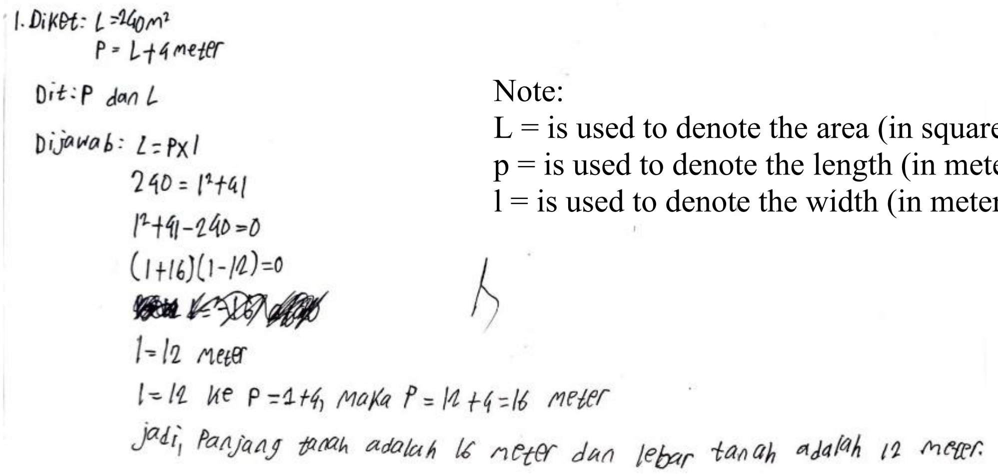
3.2 The Analytic Reasoning Process of Medium Computational Skill (S2)

This subsection explores the analytic reasoning process demonstrated by students with medium computational skills (S2). It focuses on how they understand problem situations, develop mathematical models, and carry out solution procedures, including the challenges and inconsistencies that may arise during the process.

In question 1 (Figure 3), S2 began by recalling the formula for the area of a rectangle, $L = p \times l$, where p represents the length and l the width. Recognizing that the length is 4 meters more than the width, S2 substituted p with $l + 4$, leading to the equation $240 = l^2 + 4l$. Then S2 rearranged the equation into standard quadratic form, $l^2 + 4l - 240 = 0$, and factored it as $(l + 16)(l - 12) = 0$. From the solutions $l = -16$ and $l = 12$, S2 correctly selected $l = 12$ meters, discarding the negative value (Didiş Kabar, 2023).

Jawablah soal-soal berikut dengan jawaban yang benar disertai tahapan-tahapan penyelesaian! 1. Seorang petani memiliki sebidang tanah berbentuk persegi panjang dengan luas 240 m². Jika panjang tanah tersebut 4 meter lebih panjang dari lebarnya, tentukan panjang dan lebar tanah tersebut!	English Version: **Answer the following questions with the correct solution accompanied by detailed steps of the problem-solving process!** 1. A farmer owns a rectangular plot of land with an area of 240 square meters. If the length of the land is 4 meters longer than its width, determine the dimensions (length and width) of the land!

S2's answer:



Note:
L = is used to denote the area (in square meters)
p = is used to denote the length (in meters)
l = is used to denote the width (in meters)

Therefore, the length of the land is 16 meters, and the width is 12 meters

Figure 3. Quadratic equation problems 1 and S2's answer

In this case, S2 evaluates by assessed the two solutions to the equation and made a reasonable contextual judgment by rejecting the negative root ($l = -16$) because a physical length cannot be negative (Star & Newton, 2017). The length was then calculated as $12 + 4 = 16$ meters. The final answer was clearly stated: the width is 12 meters and the length is 16 meters (Guner, 2024). In the strategy formulation phase, S2 chose factoring as the method for solving the quadratic equation. The steps taken were sequential and logical: formulating the equation, rearranging it, factoring, and then solving for the variable. This systematic approach reflects clear and organized thinking. Additional studies support that students who relate symbolic equations to real-world constraints tend to demonstrate stronger reasoning skills, particularly when determining the validity of obtained solutions (Putri et al, 2022). This is consistent with findings that making contextual judgments, such as rejecting nonrealistic values, shows conceptual understanding rather than procedural recall (Meryansumayeka et al., 2021).

S2's accurate algebraic modeling reflects flexibility in connecting geometric representations with algebraic structures (Isyrofinnisak, 2020). The orderly sequence of steps also reflects metacognitive monitoring abilities commonly found in high-performing problem solvers (Mousoulides & Christou, 2017). Furthermore, the correct application of factoring aligns with research showing that factoring remains an effective method for quadratic equation solving among high school learners (Syarifuddin et al., 2020). This progression from constructing an equation to interpreting its solutions indicates relational understanding (Star & Newton, 2017). Finally, S2's ability to justify the final answer within the real-world context demonstrates strong mathematical disposition (Mousoulides & Christou, 2017).

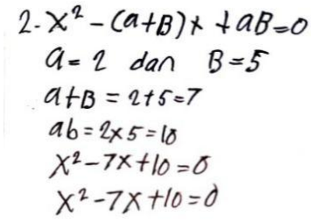
2. Jika akar-akar persamaan kuadrat adalah 2 dan 5, tentukan persamaannya!	English Version: 3. If the roots of a quadratic equation are 2 and 5, determine the equation!
S2's answer: 	

Figure 4. Quadratic equation problems 2 and S2's answer

In question 2 (Figure 4), S2 fulfills the problem identification indicator by mentioning the main information that the roots of a quadratic equation are 2 and 5 in the interview. Problem identification and key information is important because it is the initial stage of the analytic reasoning process (Afandi et al., 2022). In addition, S2 also wrote A = 2 and B = 5, which was clarified in the interview that S2 initialized the two roots of the quadratic equation known in question 2 with A and B. According to Nurrahmawati (2021), students who generalize the information in the problem show that they are able to represent written information into symbolic information. Furthermore, S2 connects the main information in question 2 with relevant concepts, namely connecting the roots of the quadratic equation into the quadratic equation formula written $x^2 - (A + B)x + (A.B) = 0$. Based on the interview, the formula was obtained from S2's memory related to the quadratic equation material that S2 had received. In the process of remembering, students reflect the activation of conceptual memory (Asanre et al, 2024). In addition, S2 also found a pattern from the main information in the form of the roots of the quadratic equation and the quadratic equation formula that S2 had written down by conveying that the sum of the roots of the quadratic equation is the pair of x variables of the quadratic equation and the product of the roots of the equation is the constant of the quadratic equation. Pattern recognition like this is a characteristic of analytical thinking skills (Septiadi et al., 2022). Furthermore, S2 formulated a solution strategy by calculating the sum of the roots of the quadratic equation and multiplying the roots of the quadratic equation written A + B = 2 + 5 = 7 and A.B = 2.5 = 10. This shows procedural and strategic thinking skills that are important in solving mathematical problems (Hamda, 2018).

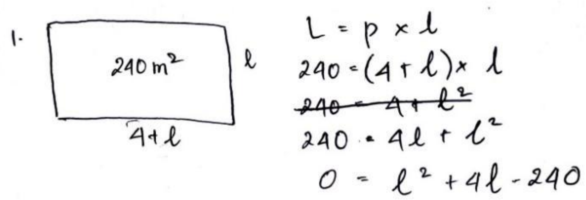
The next step S2 substituted the results of the addition and multiplication of the roots of the quadratic equation in the quadratic equation formula by writing $x^2 - 7x + 10 = 0$. This stage shows the skill to transform information into a new form that suits the purpose of the solution (Damayanti, 2019). Then S2 wrote back the result of the quadratic equation, namely $x^2 - 7x + 10 = 0$, which S2 explained in the interview as the final conclusion that the answer to the quadratic equation in question 2 is $x^2 - 7x + 10 = 0$. However, S2 did not reflect, evaluate and justify the solution because in the interview S2 said that the time for working on the problem was almost up and S2 was sure of the answer S2 wrote down. Whereas reflection, evaluation and justification are important stages in validating solutions (Asanre et al, 2024)). The lack of reflection on the answer indicates that there is still a need to strengthen students' self-evaluation skills within the analytical reasoning process (Zakaria et al., 2010). Without engaging in reflective thinking, students may fail to verify the accuracy and appropriateness of their solutions, which can lead to persistent errors and superficial understanding. Reflection, evaluation, and justification of solutions not only support the validation of results but also encourage deeper conceptual comprehension. Furthermore, these processes play a crucial role in fostering students' metacognitive abilities, enabling them to monitor, regulate, and improve their own thinking when solving increasingly complex problems in the future (Nepomucena, 2017).

3.3 The Analytic Reasoning Process of Low Computational Skill (S3)

This subsection examines the analytic reasoning process demonstrated by students with low computational skills (S3). It aims to identify how they interpret problems, construct mathematical models, and carry out solution procedures, as well as to highlight the difficulties and errors that arise throughout the reasoning process.

Jawablah soal-soal berikut dengan jawaban yang benar disertai tahapan-tahapan penyelesaian! 1. Seorang petani memiliki sebidang tanah berbentuk persegi panjang dengan luas 240 m^2. Jika panjang tanah tersebut 4 meter lebih panjang dari lebarnya, tentukan panjang dan lebar tanah tersebut!	English Version: **Answer the following questions with the correct solution accompanied by detailed steps of the problem-solving process!** 1. A farmer owns a rectangular plot of land with an area of 240 square meters. If the length of the land is 4 meters longer than its width, determine the dimensions (length and width) of the land!

S3's answer:



Note:
L = is used to denote the area (in square meters)
p = is used to denote the length (in meters)
l = is used to denote the width (in meters)

Figure 5. Quadratic equation problems 1 and S3's answer

In solving question 1 (Figure 5), initially S3 identified the problem in the problem by visualizing a piece of land by drawing a rectangular shape with a description of 240 m^2 inside the rectangle, also providing information on the symbol l for width, and $4 + l$ for length which S3 understood from the sentence "the length of the land is 4 meters longer than its width". This skill reflects the early stages in the process of solving mathematical problems, namely understanding and representing problems visually, which is important for building conceptual understanding (Afandi, 2021). In addition, in the interview, S3 can mention the main information contained in question 1, namely the area of a plot of land is 240 m^2, and the length of the land is 4 meters longer than the width. This shows that S3 has fulfilled the problem identification indicator, which reflects the skill of analytical reasoning and understanding of good mathematical concepts (Nurrahmawati, 2021). Furthermore, S3 fulfills the relationship analysis indicator because S3 analyzes and connects the information in question 1 with relevant concepts, namely connecting the area with length and width, by writing the formula for the rectangular area, namely $L = p \times l$. However, previously, based on the results of the interview S3 determined the area of the rectangle as $L = p \times l$. But previously, based on the results of the interview S3 determined the pattern or regularity in the problem in question 1 first by looking at the main information contained in the problem, namely the rectangular area = 240 m^2 and the length of the land is 4 meters longer than its width = 4 + l, so S3 associates all the known information with the concept of rectangular area.

After S3 analyzed the relationship and obtained the concept of rectangular area, S3 developed a systematic and logical solution procedure by describing and substituting the known information into the concept of rectangular area which met the indicator of solution strategy formulation by writing $L = p \times l$, followed by $240m^2 = (4 + l) \times l$. The next step S3 continued the calculation with the distribution of multiplication and wrote $240 = 4l + l^2$, followed by the final solution by compiling the previous calculation into a quadratic equation written $0 = l^2 + 4l - 240$. In solving question 1, S3 did not interpret the results of the solution according to the context of the problem because based on the results of the interview S3 felt confused and had difficulty determining the next step, which reflects the obstacles at the solution evaluation stage (Damayanti, 2019). In addition, based on the interview, S3 did not re-examine what was asked in question 1 so that S3 assumed that $0 = l^2 + 4l - 240$ was the final result of question 1.

2. Jika akar-akar persamaan kuadrat adalah 2 dan 5, tentukan persamaannya!	English Version: 2. If the roots of a quadratic equation are 2 and 5, determine the equation!

S3's answer:

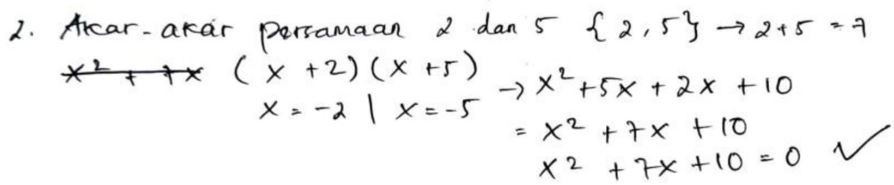


Figure 6. Quadratic equation problems 2 and S3's answer

In question 2 (Figure 6), S3 first identifies the main information by writing and mentioning in the interview that the roots of a quadratic equation are 2 and 5. This shows that S3 fulfills the problem identification indicator in the analytic reasoning process. Then S3 connects the main information in the problem with relevant concepts and determines patterns based on the information known in the problem, namely forming factors from the two roots of the equation known in the problem by writing S3 writes $x + 2)(x + 5)$ which fulfills the indicator of relationship analysis. According to (Star & Newton, 2017), the skill to connect key information in mathematical problems is essential for accurate problem solving. Although S3 wrote the factor of the roots of the quadratic equation incorrectly, because based on the interview S3 formed the factor of the roots of the quadratic equation according to the knowledge that S3 had gained.

The next step S3 formulated a solution strategy by multiplying the factors of the quadratic equation written $x^2 + 5x + 2x + 10$. Followed by simplifying the calculation by adding the numbers of variable x, namely $5x$ and $2x$ written $x^2 + 7x + 10$. Simplifying the calculation is an important step in solving mathematical problems and checking for errors (Jupri & Drijvers, 2016). Furthermore, S3 added = 0 as the final result or solution of question 2 by writing $x^2 + 7x + 10$. In this case S3 fulfills the indicator of the formulation of the solution strategy, because it has determined the strategy for solving question 2 systematically and logically according to the knowledge and understanding that S3 has obtained. Based on the interview, S3 summed up the roots of the equation, namely 2 and 5 to check whether the sum of the roots of the quadratic equation is in accordance with the variable x in the final result of the quadratic equation written by S3. Rechecking calculations is an essential component of mathematical reasoning (Nurrahmawati, 2021), although the final answer written by S3 remains incorrect due to a misunderstanding of the concept of factoring quadratic equations. In this case, S3 applied an improper factoring pattern by writing $(x+2)(x+5)$instead of the correct form $(x-2)(x-5)$for roots 2 and 5. This indicates that S3 has not fully understood the fundamental principle that if $a$and $b$are the roots of a quadratic equation, its factored form must be expressed as $(x-a)(x-b)$. This finding aligns with Star & Newton (2017), who emphasize that students' misconceptions often arise when they fail to connect algebraic procedures with the underlying conceptual meaning. Additionally, Syarifuddin et al (2020) explains that many algebraic errors occur because students overgeneralize patterns or apply rules inappropriately, particularly in symbolic operations such as factoring. By inserting a plus sign inside both parentheses, S3 demonstrates a conceptual error in understanding the relationship between roots and the correct factoring structure, ultimately resulting in an inaccurate quadratic equation.

The findings of this study reveal clear distinctions in the analytic reasoning processes of students with different levels of computational thinking ability. S1, who belongs to the high-ability category, consistently demonstrated strong problem identification, accurate translation of contextual information into mathematical models, and flexible strategy use across both quadratic equation problems. S1 showed the ability to decompose information, recognize structural patterns, and select efficient solution paths, whether through numerical reasoning or algebraic formulation. These characteristics reflect not only advanced computational thinking but also mature analytical reasoning skills, as S1 was able to justify solution steps and verify outcomes implicitly through logical consistency. This aligns with the view that strong CT supports structured problem decomposition and strategic decision-making (Elyasarikh, 2025; Wing, 2006) and enables deeper reasoning engagement in mathematical tasks (Putri et al, 2022).

Meanwhile, S2, categorized as having medium computational thinking ability, displayed reasoning patterns that were systematic and logically structured but less flexible than those of S1. S2 successfully transformed the information from contextual problems into appropriate mathematical models and applied correct algebraic procedures such as factoring in solving quadratic equations. S2's reasoning emphasized procedural fluency, supported by the ability to judge solution validity within real-world constraints. However, some aspects of analytical reasoning, particularly evaluation and reflection were not consistently demonstrated. This supports findings that students with moderate CT often show procedural adequacy but limited metacognitive monitoring (Yadav et al., 2017). Such patterns are consistent with research showing that reasoning depth depends not only on procedural knowledge but also on reflective control (Zakaria et al., 2010)

In contrast, S3, who exhibits low computational thinking ability, showed fragmented analytical reasoning characterized by difficulties in connecting concepts, forming accurate symbolic representations, and evaluating solutions. Although S3 managed to identify key information and attempt visual representation, errors emerged in translating contextual descriptions into quadratic models and in constructing algebraic factors for the given roots. These patterns indicate that low computational skill is associated with challenges in analyzing relationships, formulating strategies, and validating outcomes. Such difficulties are consistent with research showing that limited CT hinders the ability to structure problems and select appropriate strategies (Shute, 2017). Moreover, weak reasoning evaluation aligns with studies noting that students with low CT struggle to monitor and justify mathematical processes (Wells, 2018).

4 Conclusion

The findings of this study highlight clear distinctions in the analytic reasoning processes of students with different levels of computational thinking ability when solving mathematics problems based on CT-oriented tasks. Students with high CT demonstrated strong and coherent reasoning across all analytic indicators, including accurate problem identification, effective model construction, flexible strategy selection, and implicit verification of solutions. Their ability to recognize structural patterns and apply mathematical principles in both forward and reverse processes reflects a deep integration of conceptual understanding and analytical control.

Students with medium CT ability showed systematic and generally accurate reasoning, particularly in translating contextual information into algebraic representations and executing procedural steps. However, their reasoning tended to rely more heavily on fixed procedures, with limited evidence of deeper evaluation or adaptive strategy use. This suggests that while moderate CT supports procedural fluency, it may not always promote reflective judgment or metacognitive monitoring.

In contrast, students with low CT ability demonstrated fragmented reasoning, difficulties in forming correct symbolic models, and limited capacity to validate solutions. Their errors were often rooted in challenges with decomposing information, analyzing relationships, and maintaining coherence across solution steps. These patterns indicate that insufficient computational thinking skills affect not only strategy use but also the overall structure and depth of analytical reasoning.

Overall, the study concludes that computational thinking plays a significant role in shaping the quality of students' analytical reasoning in mathematics. Higher CT levels are associated with greater reasoning flexibility, stronger pattern recognition, and more effective problem-solving strategies, whereas lower CT levels correspond to inconsistent reasoning and reduced accuracy. These findings emphasize the need for instructional approaches that cultivate CT components, such as decomposition, abstraction, and algorithmic thinking,as integral elements of mathematics learning to strengthen students' analytical reasoning and enhance their performance in complex mathematical tasks.

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