International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

# Computational Thinking Of High School Students In Solving Mathematical Problems Reviewed From The Level Of Mathematical Anxiety

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**Abstract**

*Technological developments in the 21st century are increasingly influencing learning in the world of education. These technological advancements require students to develop adaptive skills in line with technological developments, one of which is computational thinking. Computational thinking is a way of thinking aimed at solving problems by utilizing basic computer science concepts, with indicators including decomposition, abstraction, pattern recognition, and algorithms. However, several studies have found that students' computational thinking skills are not yet optimal. Furthermore, high school students' mathematical problem-solving abilities are still relatively low. One factor contributing to this suboptimal ability to solve mathematical problems is math anxiety. The level of math anxiety varies from student to student. There are three levels of math anxiety: high, moderate, and low, and these differences can be influenced by many factors. Therefore, this study has a goal to describe high school students' computational thinking based on their level of math anxiety in solving mathematical problems.*

*Based on the research objectives, this study used a descriptive exploratory research approach with a qualitative approach. The study was conducted at Taman 1 State Senior High School, Sidoarjo Regency, with three 11th-grade male students with low, medium, and high levels of math anxiety as subjects. Three instruments were used: a math anxiety questionnaire, a math problem-solving task, and an interview guide. Data collection was conducted through semi-*



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*structured interviews with each subject using math problem-solving task method. Interview transcripts were then classified according to computational thinking indicators for interpretation. Based on the qualitative analysis, differences in a person's level of anxiety significantly impact their computational thinking skills.*

**Keywords: Computational Thinking; math anxiety, math problem**

## INTRODUCTION

Technological developments in the 21st century, such as artificial intelligence, machine learning, and virtual reality, are increasingly influencing the way learning is conducted in the educational world. Many learning applications can be used to provide broader access to education through these technological advancements. These technological developments require students to have adaptive skills that align with technological and information developments, one of which is computational thinking skills. Computational thinking skills are the thinking skills needed to solve problems effectively and efficiently. According to Wing (2006), computational thinking refers to thinking like a computer scientist when facing problems, where this thinking involves solving problems, designing systems, and understanding human behavior using fundamental principles in computer science. Therefore, computational thinking is a fundamental skill for all humans, not just computer scientists.

Furthermore, according to Cahdriyana and Richardo (2020), computational thinking refers to a way of thinking for problem solving through formulating computational problems and constructing problem solutions using algorithms, the aspects of which include problem decomposition, algorithmic thinking, pattern recognition, and abstraction. Furthermore, according to Kang et al. (2023), computational thinking refers to a focused approach to problem solving, combining thought processes that utilize abstraction, decomposition, algorithmic design, and evaluation. On the other hand, according to Grover and Pea (2013), computational thinking includes problem solving, system design, and understanding human nature, by utilizing the basic principles of computer science.

Based on the definitions from the researchers mentioned above, computational thinking can be defined as thinking aimed at solving problems, with indicators including decomposition, abstraction, pattern recognition, and algorithms. Computational thinking adapts the way computers think, but this doesn't mean that computational thinking must use a computer. In computational thinking, there are indicators that provide guidance or explanation mechanisms to



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achieve the goals of computational thinking. Based on research by Neo et al. (2021), there are four main indicators, also known as the four main foundations of computational thinking: decomposition, abstraction, pattern recognition, and algorithms.

Decomposition is the process of solving a problem based on the characteristics of its components, such as dividing a problem into smaller parts so that it is easier to process or gaining a better understanding of the problem by breaking it down into its component parts (Sjödahl and Eckert, 2023). Furthermore, based on this research, decomposition is categorized into two forms: substantive decomposition and relational decomposition. Substantive decomposition involves breaking down the problem into its components. Meanwhile, relational decomposition involves identifying the relationships between components.

Abstraction is the act of considering something abstractly, regardless of its associations or attributes. It refers to the process of isolating properties or characteristics common to a diverse range of objects, events, and so on without reference to the specific nature of a particular instance (Mirolo et al., 2021). Furthermore, abstraction is also characterized as the elimination of the irrelevant and the strengthening of the essential, the process of simplifying and hiding details to get to the essence of something of interest and the ability to determine which aspects are important and which are not. Thus, abstraction can be defined as a person's mental process of recognizing and understanding an object or phenomenon by ignoring or eliminating details deemed unnecessary or irrelevant.

Pattern recognition, according to Yadav et al. (2017), refers to the process of identifying visible similarities between new problems and problems solved in the past and using previous experiences to solve existing problems efficiently. This involves recognizing patterns and the associated similarities and differences between observable phenomena, which impacts problem-solving efficiency. According to Silva Junior et al. (2022), pattern recognition refers to a process of inputting stimulus information (patterns) and matching it with information in long-term memory, then recognizing the category to which the stimulus belongs. So, based on the research definition above, pattern recognition can be defined as the ability to identify similarities and differences in patterns, trends, and regularities of data and something so that it helps increase efficiency and effectiveness in solving problems and making decisions.

An algorithm, according to Leung (2021), is defined as a structured and ordered series of steps designed to solve a problem or achieve a specific goal. In the context of computational thinking, an algorithm includes a sequence of actions, conditional branches, and repetitions, and is formulated in such a way that it can be tested, repeated, and implemented as pseudocode or


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executable code. This definition is based on interviews with mathematicians and emphasizes the use of procedural steps to solve a specific goal by breaking it down into a series of steps using existing ones. These mathematicians highlight the importance of algorithmic thinking in computational thinking and its practical applications in pure and applied mathematics.

Computational thinking enables students' cognitive abilities to define patterns, break complex problems into smaller parts, organize and plan steps to obtain problem solving and create data representations through simulations (Yokuş and Kahramanoglu, 2022). Computational thinking is a step to find a solution to a problem using algorithms and the application of techniques used by software developers to write a program, but does not think like a computer (Mubarokah et al., 2023). Computational thinking can be a way to improve mathematical literacy, so that computational thinking skills can be useful for students (Fauji et al., 2022). According to Cahdriyana and Richardo (2020), computational thinking refers to a way of thinking to solve problems by formulating computational problems and building problem solutions using algorithms. Indicators include problem decomposition, abstraction, pattern recognition, and algorithmic thinking. Therefore, with computational thinking, students will be more critical so that problems can be solved well, effectively, and efficiently.

However, several studies have found that students' computational thinking skills are not optimal. A study by Rijal Kamil et al. (2021) found that many students struggle with HOT (High Order Thinking) questions related to everyday life and only understand the questions with a basic understanding. Furthermore, Azizah et al. (2022) found that students' computational thinking skills are still relatively low, as most students make mistakes in finding mathematical solutions. Furthermore, Wang et al. (2022) in their research revealed that it is necessary to improve computational thinking skills in education, including in mathematics, because computational thinking skills can improve students' understanding of STEM (Science, Technology, Engineering, and Mathematics) content, which can improve students' abilities in various aspects, one of which is solving mathematical problems.

Research by Firdausy et al. (2021) indicates that the mathematical problem-solving abilities of high school students in Indonesia are still considered low. One of the causes of students' suboptimal ability to solve complex mathematical problems is math anxiety. Math anxiety is defined as feelings of tension, worry, and anxiety that interfere with mathematical performance, number manipulation, and problem-solving abilities in everyday life and academic settings (Khasawneh et al., 2021). Research by Salahot (2022) indicates a significant impact of math anxiety on students' mathematics learning achievement. Furthermore, a study by Morsanyi


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et al. (2014) showed that math anxiety is associated with low self-confidence in one's own performance and a tendency to rush in solving problems, resulting in shorter reaction times for anxious students.

The level of math anxiety in each student can vary from one student to another, where the level of math anxiety refers to the degree of fear, anxiety, or discomfort experienced by a person when faced with situations related to mathematics. According to Rahaman et al. (2023), there are three levels of math anxiety, namely low anxiety, moderate anxiety, and high anxiety, where the difference in anxiety levels can be influenced by many factors such as personality, intellectual, and environmental factors. Furthermore, math anxiety is also indirectly linked to computational thinking skills through its association with low mathematical knowledge. Consequently, the link between students' computational thinking skills and math anxiety is such that if students' math anxiety is well managed, it will contribute to improving their computational thinking skills.

## RESEARCH METHODS

This study adopted a descriptive exploratory research methodology with a qualitative approach. Exploratory studies attempt to discover what occurs in a situation without prior explanation, which is useful when researchers want to clarify their understanding of a problem. Furthermore, the use of a qualitative approach refers to a research method that utilizes descriptive data, in the form of written or spoken language from individuals or actors that can be observed (Paul and Bandyopadhyay, 2019).

Two instruments were used in this study: the primary instrument and the secondary instrument. The primary instrument in this study refers to the researcher herself. The researcher's role in the study was as planner, implementer, data collector and analyst, data interpreter, and reporter of the research results. Furthermore, three secondary instruments were used in this study: the MAS (Mathematic Anxiety Scale) test, a Mathematics Problem-Solving Task, and an interview guide.

The Mathematical Anxiety Scale (MAS) is a test developed by Cooke et al. (2011) to assess students' levels of mathematics anxiety. The MAS test instrument consists of 13 questions, where each question has a measurement with a Likert scale consisting of five categories, namely "strongly agree", "agree", "uncertain", "disagree", and "strongly disagree", students who fill out the MAS test can fill in according to their personal conditions regarding their perspective according to the contents of the test. This test was developed by Cooke et al in 2011 to group research subjects based on high, medium, and low levels of mathematics anxiety, where the reliability


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coefficient of this test is 0.97. To determine the level of mathematics anxiety in this test by calculating the score from the mathematics anxiety questionnaire.

The Mathematics Problem Solving Assignment consists of problem sheets presented in descriptive form. Providing descriptive questions for the research subjects can help researchers understand students' computational thinking in solving mathematics problems through the subjects' answers. Linear programming was chosen as the main topic in the Mathematics Problem Solving Assignment because the problem solving in this material is quite complex, encompassing linear inequalities, linear equations, and algebra.

An interview guide was used to explore students' computational thinking. The interview guide contained points that the researcher would ask the research subjects. The purpose of using this interview guide was to ensure that no data was missed. Validation of the research instrument, a semi-structured interview, was necessary before conducting the interviews.

This research was conducted at SMA Negeri 1 Taman, Sidoarjo Regency. The researchers selected 11th-grade students as the research subjects. The reason the researcher chose grade XI as the research subject is because students at that grade level can be said to be "transitional students", where they are considered to have lived and experienced the learning process at school for a long time since entering grade X, and are starting to make adjustments at a higher level to take and reach the next level in grade XII later. The researcher chose one class as the initial research subject, to take one student from each of the three levels of mathematics anxiety, namely low mathematics anxiety, medium mathematics anxiety, and high mathematics anxiety from that class. The gender and mathematics ability of the students will be made the same, namely male students. Through this, research data will be obtained.

The data was then classified/categorized according to the computational thinking indicators, this was done to facilitate data analysis. Furthermore, if data was found that was not relevant to the computational thinking indicators, data reduction was carried out. The classified data was then presented/displayed. The data presentation was in the form of a brief description to describe students' computational thinking in solving mathematical problems in terms of their level of mathematical anxiety. The data that had been presented would be interpreted/interpreted. Through a series of qualitative analyses, conjectures related to students' computational thinking were generated in terms of their level of mathematical anxiety, namely high, medium, and low. Thus, after interpreting/interpreting the data, a conclusion was obtained regarding students' computational thinking in solving mathematical problems in terms of their level of mathematical anxiety.


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## RESEARCH RESULTS

### Computational Thinking Subject with Low Levels of Math Anxiety

Based on the findings of the analysis of the four indicators, subjects with low levels of math anxiety showed several indicators of computational thinking. In the decomposition indicator, it shows that the subject identified information from the problem into clear and separate components, such as decision variables, cost and benefit parameters, problem boundaries, and objective functions, which were expressed by the subject during the interview in table 1. Furthermore, in figure 1 is the information obtained by the subject on the Mathematical Problem-Solving Task sheet by underlining information in the problem. Skills in assessing and sorting information relevant to the problem enable the subject to not only construct a mathematical model, but also show how each piece of information plays a role in solving the problem

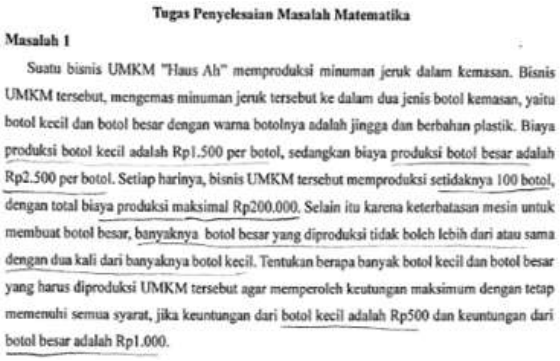
**Table 1. Interview Transcript of Low Mathematics Anxiety Subject Decomposition Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P006 | Oke, selanjutnya dari masalah yang (nama subjek 1) baca ini, kira-kira ada nggak informasi yang bisa diperoleh? Jika ada informasi yang diperoleh bisa dituliskan atau mungkin digaris bawahi saja ya! Informasi apa yang diperoleh? | Okay, next, from the problem that (subject 1's name) read, is there any information that can be obtained? If there is information obtained, can you write it down or perhaps just underline it? What information was obtained? |
| 1D006 | Ini pak, biaya produksi botol kecil 1500, biaya produksi botol besar 2500, produksinya setidaknya 100 botol, biaya produksi maksimalnya dua ratus ribu, sama ini pak banyaknya botol besar tidak boleh lebih dari atau sama dengan dua kali botol kecil. | This is sir, the production cost of a small bottle is 1500, the production cost of a large bottle is 2500, the production is at least 100 bottles, the maximum production cost is two hundred thousand, and the same as this sir, the number of large bottles cannot be more than or equal to twice the number of small bottles. |
| 1P007 | Ada lagi? | Anything else? |
| 1D007 | Keuntungan botol kecil 500, keuntungan botol besar 1000. | Small bottle profit 500, big bottle profit 1000. |



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Tugas Penyelesaian Masalah Matematika

Masalah 1

Suatu bisnis UMKM "Haus Ah" memproduksi minuman jeruk dalam kemasan. Bisnis UMKM tersebut, mengemas minuman jeruk tersebut ke dalam dua jenis botol kemasan, yaitu botol kecil dan botol besar dengan warna botolnya adalah jingga dan berbahan plastik. Biaya produksi botol kecil adalah Rp1.500 per botol, sedangkan biaya produksi botol besar adalah Rp2.500 per botol. Setiap harinya, bisnis UMKM tersebut memproduksi setidaknya 100 botol, dengan total biaya produksi maksimal Rp200.000. Selain itu karena keterbatasan mesin untuk membuat botol besar, banyaknya botol besar yang diproduksi tidak boleh lebih dari atau sama dengan dua kali dari banyaknya botol kecil. Tentukan berapa banyak botol kecil dan botol besar yang harus diproduksi UMKM tersebut agar memperoleh keutungan maksimum dengan tetap memenuhi semua syarat, jika keuntungan dari botol kecil adalah Rp500 dan keuntungan dari botol besar adalah Rp1.000.

**Figure 1. Information Obtained by Subjects with Low Math Anxiety**

Furthermore, in the abstraction indicator, subjects with low levels of math anxiety involved the separation of relevant and irrelevant information, where irrelevant information was considered unimportant, this is presented in Table 2. Subjects realized that not all details of the problem should be utilized and chose not to include data that did not support the calculation. In addition, an evaluation was carried out on the potential usefulness of information that seemed irrelevant so that some items were still considered. In Figure 2, in constructing a mathematical model, a representation was created based on the selected information, converting the narrative problem into a formal model.

**Table 2. Interview Transcript of Low Math Anxiety Subject Abstraction Indicator**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P009 | Oke, selanjutnya dari masalah yang (nama subjek 1) baca ini, kira-kira ada nggak informasi yang bisa diperoleh? Jika ada informasi yang diperoleh bisa dituliskan atau mungkin digaris bawahi saja ya! Informasi apa yang diperoleh? | Okay, next, from the problem that (subject 1's name) read, is there any information that can be obtained? If there is information obtained, can you write it down or perhaps just underline it? What information was obtained? |
| 1D009 | Ini pak, biaya produksi botol kecil 1500, biaya produksi botol besar 2500, produksinya setidaknya 100 botol, biaya produksi maksimalnya dua ratus | This is sir, the production cost of a small bottle is 1500, the production cost of a large bottle is 2500, the production is at least 100 bottles, the maximum |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | ribu, sama ini pak banyaknya botol besar tidak boleh lebih dari atau sama dengan dua kali botol kecil. | production cost is two hundred thousand, and the same as this sir, the number of large bottles cannot be more than or equal to twice the number of small bottles. |

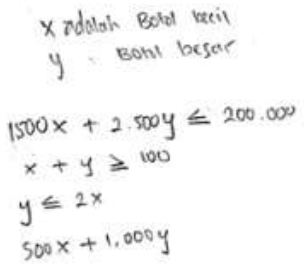



**Figure 2. Model Obtained by Subjects with Low Mathematics Anxiety**

In the pattern recognition indicator, the subject identifies relationships between numerical and functional elements in the problem. In the interview transcript in Table 3, these relationships are operationally organized by placing values into a consistent structure, for example as a boundary condition, an upper limit on another quantity, or a ratio/dependency between variables, so that separate elements become a single analytical framework. The mathematical modeling process shows the transformation of pieces of information into model components: information is grouped by value type, each value is assigned a functional role such as a decision variable, parameter, or constraint, and the relationships between values are quantitative relations. These patterns are then translated into formal notation in the form of inequalities so that the objective function and constraints emerge consistently, and the model can also be visualized graphically, as presented in Figure 3.

**Table 3. Interview Transcript of Low Math Anxiety Subject Pattern Recognition Indicator**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P010 | Nggak penting ya? Oke. Selanjutnya ini, tadi kan sudah dapat informasinya ya, kira-kira ada nggak keterkaitan antar | Not important, right? Okay. Next, we've already gathered the information, so is there any connection between the |


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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | informasi tadi. Misalnya biaya produksi berkaitan dengan apa? Atau yang lain? | information? For example, what is production cost related to? Or something else? |
| 1D010 | Biaya produksi, berkaitan dengan ini pak biaya maksimal produksinya. | Production costs, related to this, sir, are the maximum production costs. |
| 1P011 | Ada lagi nggak? Kalau nggak ada, sampaikan saja nggak apa-apa. | Is there anything else? If not, just say it's okay. |
| 1D011 | Ini banyak botol besar sama botol kecil kaitannya sama produksi maksimal botol. Sudah itu pak. | The number of large and small bottles is related to maximum bottle production. That's all, sir. |

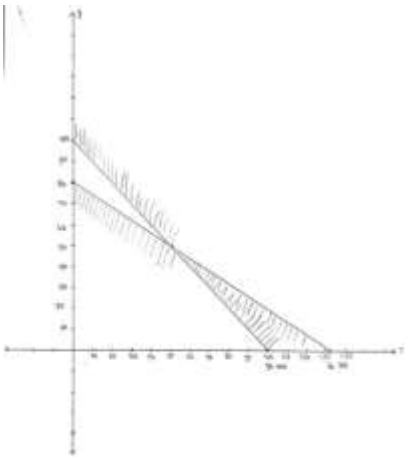


**Figure 3. Graphs Created by Low Math Anxiety Subject**

On the algorithm indicator, low math anxiety subjects described a work sequence that began with determining the relevant information of the problem. This information is sorted based on solving needs, then linked to each other to form the basis for creating mathematical models and graphic representations. Next, graphic drawing and mathematical model formulation are carried out; The intersection points and the point that produces the maximum value are determined through point calculations and tests, so that the final solution can be presented unequivocally. This process was expressed by the subject during the interview in table 4. The visible thinking process includes efficient processing of numerical information, identification of



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relationships between variables, as well as the preparation of algorithmic steps through grouping functional roles and recognizing relational patterns.

**Table 4. Interview Transcript of Low Math Anxiety Subject Algorithm Indicator**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P105 | Selanjutnya bisa nggak jelaskan langkah-langkahnya yang kamu peroleh dari awal sampai akhir sehingga kamu mendapatkan botol kecilnya itu 133, botol besarnya itu 0? Langkah-langkahnya saja, jadi saya melakukan apa dulu, selanjutnya saya melakukan apa dulu | Next, can you explain the steps you took from start to finish so that you got the small bottle 133, the big bottle 0? Just the steps, so what did I do first, what did I do next? |
| 1D105 | Ini pak apa cari informasi. | This is what sir, looking for information. |
| 1P106 | Iya informasi, habis dapat informasi? | Yes, information, after getting the information? |
| 1D106 | Dihubungkan keterkaitannya. | Connected the relationship. |
| 1P107 | Terus kita buat? | Next, we made? |
| 1D107 | Ini model. | The model. |
| 1P108 | Dari model kita… | From model, then? |
| 1D108 | Kita buat tabel, oh iya grafik | We made table, oh sorry I mean graph |
| 1P109 | Iya dari grafik kita terus apa tentukan? | Yes, from the graph, what do we determine? |
| 1D109 | Tentukan titik | Determine the points |
| 1P110 | Titiknya, terus titiknya? | The point, then the point? |
| 1D110 | Lalu dapat kesimpulan | The we have conclusion |

**Computational Thinking Subjects with Moderate Levels of Math Anxiety**

The computational thinking of subjects with moderate math anxiety showed that they followed the steps in solving math problems, although they often felt doubtful or worried about


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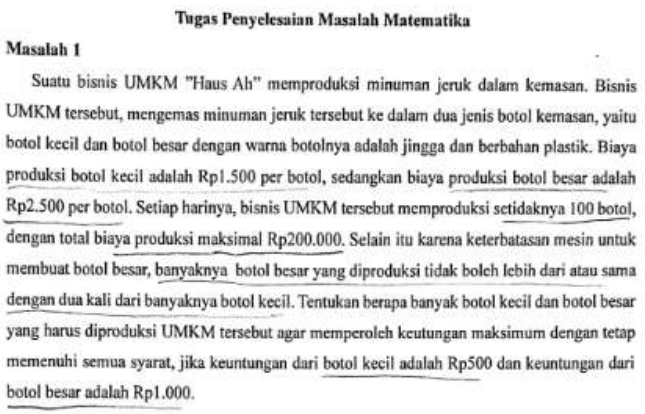
some parts of the process. In the decomposition indicator in Table 5 and Figure 4, the subjects broke down problem information into clear components, including cost and profit parameters, production constraints, and objectives, thus unraveling the problem structure. Cognitively, the subjects performed partial abstraction by grouping concrete details into conceptual categories and recognizing relationships between variables, although these relationships emerged after external prompting. This pattern indicates a structured but reactive flow of thought, where information organization proceeds well but requires additional time and support, reflecting moderate math anxiety that affects the speed and consistency of cognitive processing.

**Table 5. Interview Transcript of Moderate Mathematics Anxiety Subject Decomposition Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P004 | Dari masalah ini, kira-kira bisa beritahu saya nggak informasi apa saja yang *(nama subjek 2)* peroleh? Juga mungkin bisa digaris bawahi atau ditulis di bawahnya, informasinya saja. | From this problem, could you tell me what information (subject 2's name) obtained? You could also underline or write the information below. |
| 1F004 | Produksi botol kecilnya per botol 1500, kalau yang botol besar 2500 per botol dengan biaya produksi maksimal 200.000. | The production of small bottles is 1500 per bottle, while the production of large bottles is 2500 per bottle with a maximum production cost of 200,000. |
| 1P005 | Ada lagi nggak informasi yang bisa digali dari masalah ini? | Is there any more information that can be gleaned from this problem? |
| 1F005 | Produksi botolnya setidaknya 100 botol dan botol besar tidak boleh lebih dari atau sama dengan 2 kali dari banyaknya botol kecil. Terus keuntungan botol kecil 500, botol besar 1000. | Bottle production should be at least 100 bottles, and large bottles should not be more than or equal to twice the number of small bottles. The profit for small bottles is 500 and for large bottles, 1,000. |


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Tugas Penyelesaian Masalah Matematika

Masalah 1

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**Figure 4. Information Obtained by Subjects with Moderate Math Anxiety**

The abstraction indicator indicates a process of filtering information and adapting the mathematical model to the needs of the problem. Information that is irrelevant is not expressed, while relevant numbers and rules are mapped to variables, coefficients, and constraints. In the interview transcripts in Table 6, uncertainty initially emerged about the importance of some details, but after the researcher requested a reconsideration of the information's role in problem-solving, the decision was made to omit the irrelevant details. This decision reflects a reflective mindset focused on the modeling goal, although the rationale for assessing relevance is not explicitly explained. The model formation process is gradual: pieces of numerical information are categorized (coefficients, limits, objective functions) and then mapped to symbolic notation through a sequence of value identification → role determination → quantitative relationship formation → inequality writing. Each stage often requires an external trigger (a question or a hint) before continuing. Small errors in writing symbols and pauses in responses indicate uncertainty that affects the smooth transition from concept to formal notation, as shown in Figure 5.

**Table 6. Interview Transcript of Moderate Mathematics Anxiety Subject Abstraction Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P007 | Di dalam masalah ini kan ada yang namanya produk umkm-nya namanya haus ah, produksinya minuman jeruk, botolnya itu jingga, botolnya berbahan plastik. Itu kira-kira penting nggak | In this problem, there's an MSME product called "Haus," which produces orange drinks. The bottles are orange and made of plastic. Is that important, according to (subject 2)? |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | menurut *(nama subjek 2)*? | |
| 1F007 | Uhm… penting buat ini apa ya? | Uhm… it's important, for this, what is it? |
| 1P008 | Untuk dalam menyelesaikan masalah ini maksudnya. | In order to solve this problem, it means. |
| 1F008 | Oh itu nggak penting pak. | Oh, that's not important, sir. |

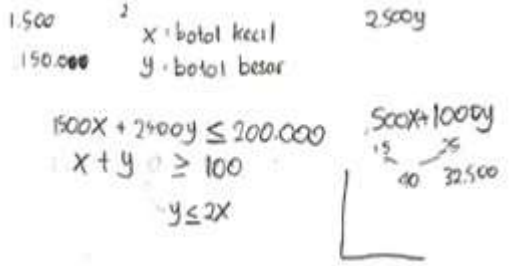



**Figure 5. Model Obtained by Subjects with Moderate Mathematics Anxiety**

In the pattern recognition indicator, initially the subject finds a connection from the existing information, but then the subject appears a little confused about finding a connection to the second information. Suspected anxiety can occur here, because the subject took a little time to express his meaning regarding the relationship between the two pieces of information, this can be seen in the interview transcript in table 7. Furthermore, the recognition of patterns in the formation of mathematical models takes place gradually and reactively: numbers are changed to coefficients, limits are changed to inequalities, and ratios are recognized as constraints; Complex relations often appear after instructions, marked by pauses and corrections when writing symbols, so that the model is formed logically but less spontaneously. However, the subject can make a graph from the information obtained by the subject, presented in Figure 6.

**Table 7. Interview Transcript of Moderate Mathematics Anxiety Subject Pattern Recognition Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P009 | Nggak penting ya. Setelah tahu informasi-informasi ini kira-kira ada | It's not important, right? After knowing this information, is there any connection |


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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | keterkaitan nggak antara informasi ini tadi? | between the information above? |
| 1F009 | Apa tadi bisa diulang? | What, can you repeat that? |
| 1P010 | Keterkaitan antar informasinya misalnya keterkaitan biaya produksi atau laba yang diterima atau mungkin keuntungannya. Keterkaitan antar informasinya tadi. misalnya biaya produksi botol itu kaitannya sama apa? | The relationship between the information, for example, relates to production costs or profits, or perhaps the gain. The relationship between the information mentioned earlier, for example, what is the relationship between bottle production costs? |
| 1F010 | Iya... eh... yang kecil itu harus 1500 per botol, terus yang besar itu 2500 per botol sama biaya maksimalnya 200.000. Terus maksimalnya, eh biasanya memproduksinya setidaknya 100 botol. Produksinya tidak boleh lebih dari… tidak boleh lebih dari atau sama dengan dua kali dari banyaknya botol kecil jadi kalau sepaham saya produksi botol besar itu tidak boleh lebih atau sama dengan dua kalinya, dua kali dari banyaknya botol kecil. | Yes... uh... the small ones have to be 1500 per bottle, then the large ones are 2500 per bottle with a maximum cost of 200,000. Then the maximum, uh usually produce at least 100 bottles. The production cannot be more than... cannot be more than or equal to twice the number of small bottles so if I understand the production of large bottles should not be more than or equal to twice, twice the number of small bottles. |
| 1P011 | Mungkin gini ya maksudmu jadi kayak banyaknya botol itu harus setidaknya 100 itu kaitanya sama yang produksi botol besar tidak boleh lebih dari atau sama dengan dua kali botol kecil. Terus yang tadi biaya produksi botol kecil dan botol besar kaitannya sama yang biaya produksi maksimal 200.000. Apakah | Maybe this is what you mean, so the number of bottles must be at least 100, which is related to the production of large bottles, which cannot be more than or equal to twice the production of small bottles. Also, the production costs of small bottles and large bottles are related to the maximum production cost of 200,000. Is |


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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | ada lagi kaitannya? | there another connection? |
| 1F011 | Iya begitu pak, sudah sih pak. | Yes, sir, that's all, sir. |

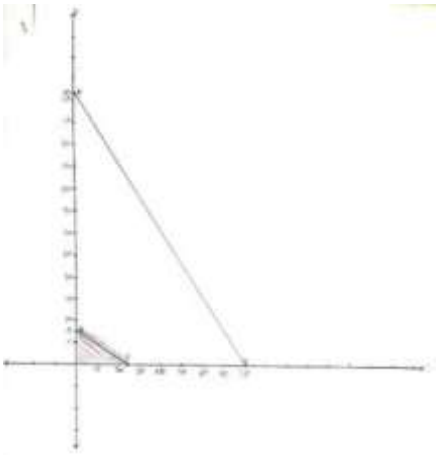


**Figure 6. Graphs Created by Moderate Math Anxiety Subject**

In the algorithm indicator, subjects with moderate math anxiety follow sequential algorithmic steps: collecting and sorting information, defining variables, forming constraints and mathematical models, drawing graphs to determine the feasible region, and then evaluating the objective function at candidate points, as can be seen in table 8. This process is deterministic yet reactive, each step occurring gradually and often triggered by prompts, with small pauses and corrections marking repeated verifications before the final decision.

**Table 8. Interview Transcript of Moderate Math Anxiety Subject Algorithm Indicator**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P081 | Jadi bisa kamu simpulkan nggak apa langkah-langkah dari awal sampai akhir. Langkah-langkahnya saja nggak usah kamu sebutkan tadi masukkan ini, masukkan ini. | So, can you summarize the steps from start to finish? You don't need to mention the steps just now—enter this, enter this. |
| 1F081 | Iya pak. | Yes, sir. |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P082 | Pertama kayak apa? | What was it like at first? |
| 1F082 | Pertama baca soalnya terus kalau ada 2 botol besar dan botol kecil itu dijadikan x dan y, misal x botol kecil dan y botol besar. Nah x dan y ini ditambah sama terus dikasih kurang dari biaya produksinya, biaya produksi maksimal itu 200.000. Terus nanti dapat 1500x ditambah 2500y kurang dari 200.000 dan seterusnya. | First, read the problem and then if there are 2 large bottles and a small bottle, they are made into x and y, for example x is a small bottle and y is a large bottle. Now, x and y are added together and then given less than the production cost, the maximum production cost is 200,000. Then later you get 1500x plus 2500y less than 200,000 and so on. |
| 1P083 | Atau singkatnya membuat model matematika ya. | Or in short, make a mathematical model. |
| 1F083 | Iya pak | Yes, sir. |
| 1P084 | Lalu setelah itu? | Then, after that? |
| 1F084 | Iya membuat grafik pak | Yes, I made a graph, sir. |
| 1P085 | Setelah membuat grafik kemudian? | After making the graph then? |
| 1F085 | Menghitung 1500x kurang dari 200.000, ibaratkan kalau x itu 0 dan y-nya 80 karena mencari y dulu. Sudah ketemu, dari produksi maksimal dikasih titik dan ditarik garis, terus yang produksi maksimalnya 100 botol dibuat lagi seperti yang tadi. Udah ketemu dikasih titik dan ditarik garis lagi. Lalu mencari daerah hasilnya. | Calculating 1500x is less than 200,000, imagine that x is 0 and y is 80 because we are looking for y first. Once found, a dot is placed on the maximum production and a line is drawn, then the maximum production of 100 bottles is made again as before. Once found, a dot is placed on the maximum production and a line is drawn again. Then find the resulting area. |
| 1P086 | Daerah hasilnya ketemu selanjutnya apa? | What area will the results meet next? |
| 1F086 | Titiknya tadi dimasukkan ke yang 500x ditambah 1000y, dari ceritanya | The point was entered into the 500x plus 1000y, from the story the profit from the |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | keuntungan dari botol kecil adalah 500 dan keuntungan dari botol kecil adalah 1000. | small bottle is 500 and the profit from the small bottle is 1000. |
| 1P087 | Setelah itu? | After that? |
| 1F087 | Nanti ketemu hasilnya pak yang 32500. | Later we will find the results, sir, which are 32,500. |
| 1P088 | Berarti nanti ketemu 32500. Berarti produksi botol kecil dan botol besarnya adalah? | So, we will meet 32500. So, what is the production of small bottles and large bottles? |
| 1F088 | Botol kecil produksinya ada 15 botol besar 25. | The production of small bottles is 15 and large bottles are 25. |
| 1P089 | Oke berarti kamu narik kesimpulannya itu ya? | Okay, so you drew that conclusion, right? |
| 1F089 | Iya pak. | Yes, sir. |

**Computational Thinking Subjects with High Levels of Math Anxiety**

Furthermore, in subjects with high levels of math anxiety, based on the analysis of computational thinking indicators, subjects showed that they faced greater challenges in solving math problems compared to students with low or moderate anxiety. In the decomposition indicator, subjects showed a tendency to search for and read all the information in the problem to ensure no details were missed. In Table 9 and Figure 7, in contrast to subjects with low and moderate levels of math anxiety who focused on mathematical data, subjects not only identified quantitative information (such as unit cost, budget constraint, minimum production limit, variable ratio, and objective function) but also mentioned non-quantitative contextual elements. This effort to absorb all the information without separating the relevant from the irrelevant actually presented a significant challenge in breaking the problem down into smaller parts. Consequently, the subjects' decomposition style became overly cautious and heavily reliant on external assistance, where information had to be broken down into small units and repeatedly verified before being modeled. While this approach was effective in reducing the risk of major errors, it slowed efficient thinking, triggered frustration, and reduced spontaneity in organizing problem


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components.

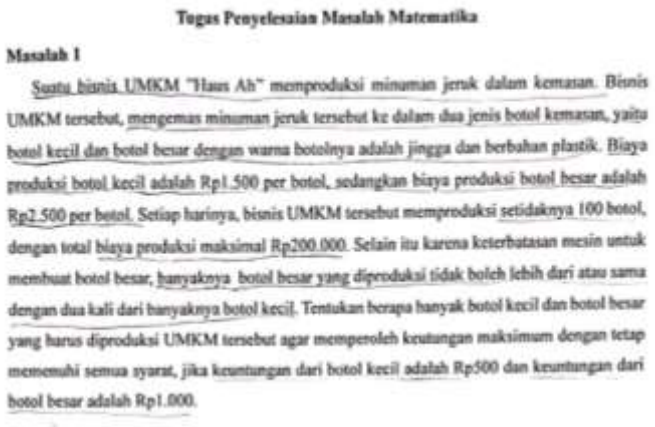
**Table 9. Interview Transcript of High Mathematics Anxiety Subject Decomposition Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P006 | Oke, eh setelah membaca masalah ini tadi kira-kira ada nggak informasi yang *(nama subjek 3)* dapatkan dari masalah ini tadi? Mungkin bisa dituliskan atau digarisbawahi. Mau pakai pensil atau pulpen terserah. | Okay, after reading this problem, is there any information that (subject 3's name) can get from this problem? Perhaps you could write it down or underline it. It's up to you whether you want to use a pencil or a pen. |
| 1A006 | Yang saya pahami itu yang biayanya pak, biaya produksi botol kecil dan biaya produksi botol besar adalah 2500 per botol. | What I understand is that the cost, sir, is the production cost for small bottles and the production cost for large bottles is 2500 per bottle. |
| 1P007 | Mungkin digaris bawahi saja ya. Ada lagi informasi yang bisa diperoleh dari masalah ini? | Maybe just underline it. Is there any other information we can glean from this issue? |
| 1A008 | Biaya produksi botol kecil adalah 1500 per botol, sedangkan biaya produksi botol besar adalah 2500 per botol biaya produksi maksimal 200.000, terus sama banyaknya botol besar yang diproduksi tidak boleh lebih dari atau sama dengan dua kali dari banyaknya botol kecil. Keuntungan botol kecil 500, keuntungan botol besar 1000. | The production cost of a small bottle is 1500 per bottle, while the production cost of a large bottle is 2500 per bottle, the maximum production cost is 200,000, and the number of large bottles produced cannot be more than or equal to twice the number of small bottles. The profit for a small bottle is 500, the profit for a large bottle is 1000. |
| 1P009 | Oke ada lagi? Kalau nggak ada bilang saya. | Okay, is there anything else? If not, tell me. |
| 1A009 | Suatu bisnis umkm haus ah memproduksi minuman jeruk dalam kemasan, sama mengemas minuman | A small and medium enterprise business is thirsty for producing packaged orange drinks, and packaging the orange drinks |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | jeruk tersebut ke dalam dua jenis botol kemasan yaitu botol kecil dan botol besar dengan warna botolnya adalah jingga dan berbahan plastik. | into two types of bottles, namely small bottles and large bottles, with the bottles being orange and made of plastic. |



Tugas Penyelesaian Masalah Matematika

Masalah 1

Suatu bisnis UMKM "Haus Ah" memproduksi minuman jeruk dalam kemasan. Bisnis UMKM tersebut, mengemas minuman jeruk tersebut ke dalam dua jenis botol kemasan, yaitu botol kecil dan botol besar dengan warna botolnya adalah jingga dan berbahan plastik. Biaya produksi botol kecil adalah Rp1.500 per botol, sedangkan biaya produksi botol besar adalah Rp2.500 per botol. Setiap harinya, bisnis UMKM tersebut memproduksi setidaknya 100 botol, dengan total biaya produksi maksimal Rp200.000. Selain itu karena keterbatasan mesin untuk membuat botol besar, banyaknya botol besar yang diproduksi tidak boleh lebih dari atau sama dengan dua kali dari banyaknya botol kecil. Tentukan berapa banyak botol kecil dan botol besar yang harus diproduksi UMKM tersebut agar memperoleh keutungan maksimum dengan tetap memenuhi semua syarat, jika keuntungan dari botol kecil adalah Rp500 dan keuntungan dari botol besar adalah Rp1.000.

**Figure 7. Information Obtained by Subjects with High Math Anxiety**

In the abstraction indicator, the subject exhibited a pattern of abstraction that was partial, reactive, and dependent on external guidance. In the interview transcript in Table 10, the subject initially included irrelevant contextual details for fear of missing something, then switched to numbers (costs, limits, profits) after being directed. The transition to symbols and coefficients was accompanied by confusion, typos, and repeated corrections, resulting in a slow abstraction process that required repeated verification. The resulting abstraction was ultimately complete, but the process was slow, fraught with verification, and dependent on external scaffolding. However, through this, the subject was able to construct a mathematical model of the problem using previously acquired information, as shown in Figure 8.

**Table 10. Interview Transcript of High Mathematics Anxiety Subject Abstraction Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P011 | Tadi kan *(nama subjek 3)* kan menyebutkan kalau ada umkm namanya haus ah, terus jeruk eh | Earlier, (subject 3) mentioned that there's an MSME called "haus ah," and then "Orange," which produces orange drinks, |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | memproduksi minuman jeruk, botolnya jingga dan bahannya plastik. Itu kira-kira diperlukan nggak untuk menyelesaikan masalah ini? | the bottles are orange and made of plastic. Do you think that's necessary to solve this problem? |
| 1A011 | Iya diperlukan biar bisa mengemas itu. | Yes, it is necessary to be able to package it. |
| 1P012 | Maksudnya dalam inti masalahnya kan masalahnya kan adalah berapa botol besar botol kecil harus diproduksi kan? Kira-kira perlu nggak informasi kayak botolnya berbahan plastik terus namanya harus haus ah? | I mean, the core of the problem is how many large and small bottles should be produced? Do you think it's necessary to have information like the bottles are made of plastic and the name has to be thirsty? |
| 1A012 | Iya, biar nggak keliru dengan makanan lainnya. | Yes, so as not to be confused with other foods. |

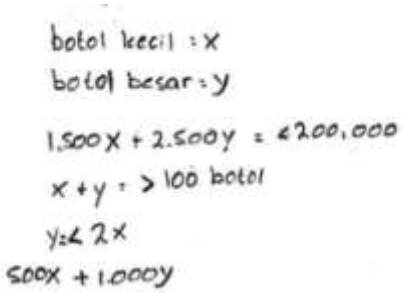



**Figure 8. Model Obtained by Subjects with High Mathematics Anxiety**

In the pattern recognition indicator, the subject proceeds gradually and reactively. In the interview transcript in Table 11, numerical elements such as costs, budget limits, minimum amounts, ratios, and profits are identified, then grouped according to their functional roles (coefficients, constraints, objectives) and paired with relevant mathematical operations. However, the association between information often requires external guidance, so complex relationships only emerge after a stimulus from the researcher. This process is characterized by


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pauses, sign corrections, and repeated verification before the pattern is considered complete. Cognitively, the thinking pattern is pragmatic and goal-oriented, with a priority on relevant information, the use of graphs as testing tools, and limited working memory that makes the integration of multiple limits fragmentary and cautious. However, based on the information obtained, the subject made the graph presented in Figure 9.

**Table 11. Interview Transcript of High Mathematics Anxiety Subject Pattern Recognition Indicators**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P013 | Terus antar informasi yang *(nama subjek 3)* temukan, ada nggak kira-kira keterkaitannya misalnya biaya produksi itu terkait dengan apa? Terus banyaknya botol besar dan botol kecil itu terkait dengan apa gitu. | So, considering the information (subject 3's name) found, is there any connection? For example, what is the production cost related to? And what is the relationship between the number of large and small bottles? |
| 1A013 | Kalau memproduksi minuman jeruk dalam kemasan kan harus pak minuman terus... (*diam untuk waktu yang cukup lama*) | If you produce bottled orange drinks, you have to keep packing the drinks... *(silence for quite a long time)* |
| 1P014 | Misal biaya produksi itu kan berkaitan dengan apa? | For example, what are production costs related to? |
| 1A014 | Biaya produksi kaitan sama yang biaya botol kecil 1500 botol besar 2500, mungkin sama yang 200.000 itu pak. | The production costs are the same as the cost of a small bottle of 1500 and a large bottle of 2500, maybe the same as the 200,000, sir. |
| 1P015 | Oke ada lagi? | Okay, anything else? |
| 1A015 | Produksi lebih dari 100. Terus keuntungan botol kecil 500 botol besar 1000. | Production more than 100. Then the profit of small bottles 500 large bottles 1000. |
| 1P016 | Jadi seperti itu ya keterkaitan antar informasinya ya, ada lagi? | So that's how the information is related, is there anything else? |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1A016 | Iya pak sudah. | Yes sir, that's enough. |

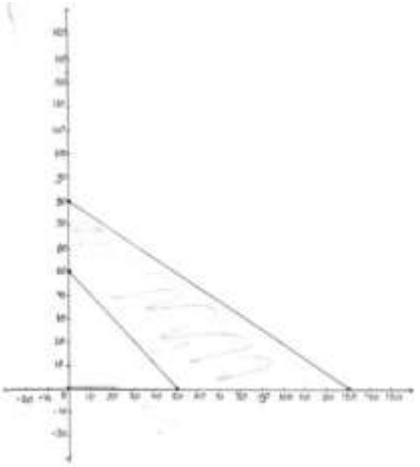


**Figure 9. Graphs Created by High Math Anxiety Subject**

In the algorithm indicator, the algorithmic steps described by the subject are sequential but fragmented. In the interview transcript (Table 12), the process begins with gathering numerical information, defining variables, establishing constraints, constructing graphs, identifying test points, and evaluating the objective function. Although following a classic algorithmic scheme (input → transformation → evaluation), execution is frequently interrupted by pauses, sign corrections, and clarifications from the researcher, making the transition between steps more reactive than spontaneous. Cognitively, information is processed in small units to reduce errors, with repeated verification slowing the integration of multiple constraints. Interaction with the researcher serves as an important scaffolding that encourages continuation of the process and corrects symbolic errors, so the algorithmic flow remains logical but less fluid and heavily dependent on external confirmation.

**Table 12. Interview Transcript of High Math Anxiety Subject Algorithm Indicator**

| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1P119 | Tadi kita kan ketemu 133 banyak botol kecil kan 133. Bisa sebutkan itu nggak | Earlier you found 133, there were many small bottles, right? 133. Can you mention |


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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| | langkah-langkahnya yang kamu temukan dari awal sampai akhir sampai ketemu 133 ini. Misal saya menemukan informasi ini, lalu informasinya saya kaitkan. | the steps you found from start to finish until you found 133? For example, I found this information, then I linked the information. |
| 1A119 | Bagaimana? | How? |
| 1P120 | Langkah-langkahnya yang kamu dapatkan itu. | Those are the steps you get. |
| 1A120 | Langkah-langkahnya itu sama kayak gini, dari 1500 dikurangi 2500y lebih dari (*membenarkan kalimat)* kurang dari 200000 terus oh ini dari keuntungan botol kecilnya 500 terus botol besarnya 1000. Terus itu dihitung kayak apa namanya? | The steps are the same as this, from 1500 minus 2500, it is more than (correct the sentence) less than 200000, then oh, this is from the profit of the small bottle which is 500, then the big bottle is 1000. So, what is the calculation called? |
| 1P121 | Kita membuat model matematikanya dulu kan? | We make the mathematical model first, right? |
| 1A121 | Iya. | Yes. |
| 1P122 | Dari model ini kita masukkan ke? | From this model we enter into? |
| 1A122 | Ke model matematika. | To mathematics model. |
| 1P123 | Selanjutnya? | Next? |
| 1A123 | Membuat grafik ini pak. | Make this graph sir. |
| 1P124 | Terus setelah membuat grafik? | So, after making the graph? |
| 1A124 | Kita tinjau titik-titiknya. | We review the points |
| 1P125 | Terus habis itu? | After that? |
| 1A125 | Terus kita akan cari yang paling besar. | Then we will look for the biggest one. |
| 1P126 | Dengan cara? | How? |



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| Code | Interview Transcript (Indonesian) | Interview Transcript (English) |
|---|---|---|
| 1A126 | Kita masukkan ke sini (*menunjuk ke fungsi objektif*). | We enter it here *(points to the objective function)*. |
| 1P127 | Oke terus? | Okay, next? |
| 1A127 | Iya ketemu solusinya. | Yes, we found the solution. |

**Similarities and Differences in Computational Thinking of the Three Subjects**

About the similarities and differences in the thinking of the three subjects on each computational thinking indicator. In the decomposition indicator, all three subjects demonstrated similarities in computational thinking. All three subjects identified information from the problem into clear and separate components, such as decision variables, cost and benefit parameters, problem boundaries, and the objective function. All subjects highlighted key figures (cost, budget limit, minimum amount, ratio, and profit) as the basis for decomposition before proceeding.

Although all three subjects shared similarities in naming several key pieces of information, such as decision variables, cost and benefit parameters, problem boundaries, and the objective function, there were striking differences in the decomposition indicators they provided. Subjects with low math anxiety and subjects with moderate math anxiety, despite having different levels of math anxiety, did not mention additional information related to non-mathematical aspects. Conversely, subjects with high levels of math anxiety showed a tendency to search and reread all information in the problem repeatedly to ensure no details were missed.

In the abstraction indicator, the three subjects demonstrated similarities in their problem-solving approaches. Despite varying levels of math anxiety, they consistently used mathematical models as the primary method for solving the given problems. They identified key elements of the problem and formulated relationships between relevant variables through mathematical inequalities, such as cost parameters, problem constraints, and objective functions. This indicates that, despite varying levels of math anxiety, all three subjects demonstrated the ability to generalize and structure problems in a more systematic way to facilitate solution (Suttrisno, et al., 2025).

However, there were differences in the abstraction indicator in how the three subjects considered the relevance of information not directly related to the problem. The subject with low levels of math anxiety explicitly stated that irrelevant information was unimportant in solving the problem. Their approach focused more on sorting out information that directly supported the


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mathematical problem solving, ignoring information deemed unrelated. The subject with moderate levels of math anxiety initially stated that irrelevant information was unimportant, but later changed their perspective, realizing that some seemingly irrelevant information might actually provide additional context for understanding the problem. Meanwhile, subjects with high levels of math anxiety believed that information that was irrelevant to the problem was actually crucial to solving it. They believed that each piece of information, even if seemingly unrelated, could provide broader insights and help build a more comprehensive understanding of the problem (Misbahrudin, et al., 2026). This difference illustrates how math anxiety levels influence how subjects abstract and process information in problem-solving.

In the pattern recognition indicator, the three subjects demonstrated similarities in how they recognized patterns of relationships between existing information. Despite differences in their levels of math anxiety, all three were able to identify the same relationship, specifically the relationship between product production costs and the maximum production cost. They understood that these production costs had certain limits that could not exceed the predetermined maximum cost, indicating a consistent pattern in their approach to the problem. Furthermore, the process of translating relationships into mathematical notation and/or graphs appeared in all subjects as part of the problem modeling.

The differences in the pattern recognition indicator were evident between the three subjects in how they connected information related to the given problem. In subjects with low levels of math anxiety, the associations between elements emerged more spontaneously and integratedly; several relationships could be connected simultaneously. Subjects focused on the quantitative relationship between costs and production quantities without paying much attention to other contexts. In subjects with moderate levels of math anxiety, the associations occurred gradually; the first relationship was quickly recognized, while subsequent relationships required time and clarification. In subjects with high levels of math anxiety, the associations were reactive; complex relationships emerged only after external guidance and were often fragmented. Subjects expanded the pattern of associations by incorporating profit factors into production analysis.

In terms of algorithmic indicators, all three subjects at each level of math anxiety followed the same basic algorithmic scheme: information collection and sorting → variable determination → constraint/model formulation → visual representation (graph) → candidate point identification → objective function evaluation. The sequence of steps described was linear and deterministic across all subjects, so the procedural structure (input → transformation → evaluation) was consistent across anxiety levels. All subjects also used graphs and point tests to select the optimal


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solution, indicating a similarity in problem-solving strategies at the procedural level.

However, there were significant differences in the order and emphasis of the steps they described. In subjects with low math anxiety, the steps proceeded relatively spontaneously and integrated, transitions between stages were smoother, and the amount of verification was minimal, resulting in more efficient algorithm execution. The process focused more on basic, intuitive steps to reach a conclusion. In subjects with moderate math anxiety, the sequence is maintained but slower, with small pauses and corrections occurring when writing symbols or assessing the relevance of information, so the process is reactive and requires occasional prompting. In subjects with high math anxiety, the sequence is present but fragmented. Each step is often processed in small units with repeated verification, initiation of the next step tends to be triggered by external prompts, and integration of multiple constraints is slow.

## CONCLUSION

Based on the results of the qualitative analysis, it can be concluded that differences in an individual's level of anxiety have a significant qualitative impact on computational thinking skills. This suggests that variations in anxiety intensity not only impact an individual's psychological state but also impact how they process information, develop problem-solving strategies, and develop systematic thought patterns in the context of computational thinking.

Based on the research findings, it is recommended that future researchers expand the scope of the study by replicating this research on more specific mathematics topics (e.g., algebra, geometry, calculus, number and operations, measurement) to test the generalizability of the pattern of anxiety's influence on computational thinking. Furthermore, the use of a mixed methods design that combines standardized quantitative instruments to measure mathematics anxiety and computational thinking skills with in-depth qualitative analysis will strengthen the validity of the findings and help map the cognitive and affective mechanisms underlying performance differences.

For educational practice, the results of this study encourage the development of teaching strategies that are sensitive to students' anxiety levels. Teachers and curriculum developers are advised to provide formative rubrics that assess aspects of decomposition, abstraction, pattern recognition, and algorithms so that interventions can be targeted to individual needs. Experimental interventions testing anxiety reduction techniques (relaxation training, positive reinforcement, collaborative learning) are also recommended to assess causal effects on computational thinking abilities.


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