

## STUDENTS COMBINATORIC THINKING PROCESS IN SOLVING TIMSS PROBLEMS VIEWED FROM THINKING STYLE

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### Abstract

Students' different thinking styles would affect intelligence in managing and compiling the mind to understand easily, quickly, and effectively in solving problems. Thinking styles can also be influenced by students' habits when participating in classroom learning and students' habits when studying at home. This study aims to describe students' combinatoric thinking processes in solving TIMSS problems of thinking style. This study type is descriptive with a qualitative approach. The instruments used were questionnaires, test questions, and interviews. Questionnaires were used to classify students' thinking styles, test questions were used to find combinatoric thinking processes, and interviews were used for clarification and additional information to ensure the emergence of combinatoric thinking process indicators. This study's subjects were four of Assyfa Learning Center Foundation students. The selection of subjects is based on concrete sequential, abstract sequential, abstract random, and concrete random thinking styles. Then the subject is given a question test to determine the achievement indicators in the combinatoric thinking process. In a concrete sequential thinking style, the subject works on the problem in detail, step by step. Subjects with an abstract sequential thinking style in working on questions according to the concept. Meanwhile, subjects with random thinking styles, both concrete and abstract, solved problems randomly, and several concepts were not written down in detail

**Keywords:** Thinking Styles; Combinatory Thinking Processes, TIMSS.

### Abstrak

Perbedaan gaya berpikir siswa akan mempengaruhi kecerdasan dalam mengelola dan menyusun pikiran untuk memahami dengan mudah, cepat, dan efektif dalam memecahkan masalah. Selain itu, gaya berpikir juga dapat dipengaruhi oleh kebiasaan siswa ketika mengikuti pembelajaran di kelas dan kebiasaan siswa ketika belajar di rumah. Penelitian ini bertujuan untuk mendeskripsikan proses berpikir kombinatorik siswa dalam memecahkan soal TIMSS ditinjau dari gaya berpikir. Jenis penelitian ini adalah deskriptif dengan pendekatan kualitatif. Instrumen yang digunakan yaitu angket, tes soal, dan wawancara. Angket digunakan untuk mengelompokkan gaya berpikir siswa, tes soal digunakan untuk mengetahui proses berpikir kombinatorik, dan wawancara untuk klarifikasi dan tambahan informasi untuk memastikan pemunculan indikator proses berpikir kombinatorik. Subjek penelitian ini adalah 4 siswa dari Bimbingan Belajar Assyfa. Pemilihan subjek berdasarkan gaya berpikir sekuensial konkret, sekuensial abstrak, acak abstrak dan acak konkret. Kemudian subjek tersebut diberikan tes soal, untuk mengetahui pencapaian indikator pada proses berpikir kombinatorik. Pada gaya berpikir sekuensial konkret, subjek mengerjakan soal secara detail langkah demi langkah. Subjek dengan gaya berpikir sekuensial abstrak dalam mengerjakan soal sesuai konsep. Sementara itu, subjek dengan gaya berpikir acak, baik konkret maupun abstrak menyelesaikan soal secara acak dan terdapat beberapa konsep yang tidak dituliskan secara detail.

**Kata kunci:** Gaya Berpikir, Proses Berpikir Kombinatorik; TIMSS.



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## INTRODUCTION

The Third International Mathematics and Science Study (TIMSS) is an international assessment and assessment project designed to assess fourth-grade elementary and eighth-grade mathematics and science achievement and collect data on its implementation. Through this, teachers can use it to improve the teaching and learning process in mathematics and science (ALRwaythi & AL-Otaibi, 2020; Eriksson et al., 2019; Wardat et al., 2022). TIMSS develops content domains and cognitive mathematical judgments, including numbers, algebra, geometry, data, and probability. The cognitive domain includes knowing facts and procedures (knowledge), using concepts and solving routine problems (application), and solving non-routine problems (reasoning) (Schoenfeld, 2016; Yazgan et al., 2021). In TIMSS math problems, certain problem-solving aspects can be applied to investigate when faced with deeper problem-solving (Arifani et al., 2017; Elvira et al., 2015).

TIMSS results show that Indonesian students' general ability is still deficient, especially in mathematics (Nahadi et al., 2021; Nur & Palobo, 2018; Ramadhani & Yulianto, 2020). Learning involves a mental process in the human brain, so learning is an activity related to thought processes (Aprilia et al., 2017). In order to the thinking process, the teacher's role is significant to support the development of students' thinking processes; namely, the teacher asks questions about what has been learned to understand the material given before or after learning (Mawardi et al., 2020)

Combinatorics can be used to train students to count, make estimates, generalize, and think systematically

(Rahmi & Zamista, 2020). Combinatorial can direct students to understand the strengths and limitations of mathematics (Irawandi et al., 2021). Combinatoric thinking includes higher-order thinking skills. Zunaiedy et al. (2019) mentioned that critical and creative thinking skills are needed when solving combinatorics problems. So it is necessary to familiarize students with exercises that stimulate combinatoric thinking skills, such as TIMSS questions.

Manohara et al. (2019) showed that five auditory students could use concepts and competencies to provide combinatoric reasoning. The subject did not show the maximum problem-solving acquisition at the interview stage. Wahyuni et al. (2018) two of the four research subjects are classified at level 4 in the combinatoric thinking process, and other students are classified at levels 1 and 2. Students can complete and explain work and develop their understanding.

Based on previous research, students still have difficulty solving questions, especially with the TIMSS model. Students are always focused on fixed formulas without looking for other alternative ways. Students are less able to analyze the information obtained and tend to ignore the information. The factor that causes students to feel difficulty is a lack of conceptual understanding due to differences in student abilities.

Students' different thinking styles would affect their intelligence in thinking (Adha & Rahaju, 2020). Thinking style is managing and compiling data in each individual's mind (Firdaus et al., 2019). Someone who knows their thinking style will find it easier to choose the steps needed so they can understand easily, quickly, and

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effectively in solving problems (Çelik, 2019). According to Gregorc, four combination behaviors in managing and compiling information are called thinking styles.

Research conducted by (Putri et al., 2022) about thinking styles according to Stenberg, namely legislative, executive, and judicial styles. Research conducted by Haryati and Kholid on thinking styles, analytic, visual, and integrated. Other research on combinatoric thinking (Manohara et al., 2019) combinatoric thinking processes with auditory learning styles. Wahyuni et al. (2018) stated a combinatoric thinking process in solving sequence and series problems.

The difference is that this study uses Gregorc's thinking styles, including Concrete Sequential (CS), Abstract Sequential (AS), Concrete Random (CR), and Random Abstract (RA) (A Putri et al., 2021; Krisdiantoro & Prihatnani, 2019; Sahatcija et al., 2017). The difference with this study was seen from the students' thinking style using the TIMSS model questions with System of Two Variable Linear Equations (SPLDV) in class VIII.

This study is vital because combinatoric thinking allows students to build ideas from answers. Students can use different ideas/formulas in solving problems, which will result in different solving processes depending on the way students think in solving problems. This study aims to describe students' combinatoric thinking processes in solving TIMSS problems in thinking styles.

## RESEARCH METHOD

This study type used descriptive research and a qualitative approach. Descriptive research, namely, the researcher describes the combinatoric

thinking process of class VIII junior high school students on mathematics problems in the SPLDV material. A qualitative approach is used to find out the combinatoric thinking processes of junior high school students in solving TIMSS questions on SPLDV material in thinking style.

Four subjects were randomly selected from grade VIII Assyfa Learning Center Foundation students. Data collection techniques in this study were questionnaires, written tests, and interviews. The questionnaire adopted by Hernacki & De Porter (2015) in the Quantum Learning book was given to Grade VIII students in junior high school to determine their thinking style. The subject codes are SK, SA, RA, and RK. Questionnaires are used to classify students' thinking styles. Subjects selected from as many as four students will be given a description test related to combinatoric thinking in the SPLDV material.

Written tests were used to find combinatoric thinking processes, and interviews for clarification and additional information were used to ensure the emergence of combinatoric thinking process indicators. The data analysis technique in this study is a data analysis technique from Miles et al. (2018), data collection, data condensation, data display, and conclusion in Figure 1.

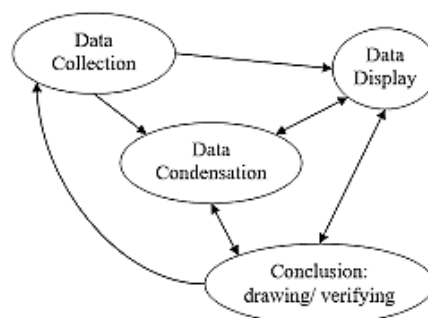


Figure 1. Qualitative data analysis techniques





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d). Kacamata =  $4 \times 20.000 = 80.000$   
 Bandana =  $6 \times 8.000 = 48.000$  +  
 $\text{Rp. } 128.000$   
 Jadi, untuk membelikan temannya souvenir dengan catatan lebih banyak bandana dari kacamata dan satu temannya mendapat satu souvenir (kacamata atau bandana), uang yang harus dibayar dinda adalah sebesar Rp. 128.000

Figure 5. CS Subject Answer

Figure 5 represents the last stage of the combinatoric thinking process, namely changing other combinatorics problems. The question is how many souvenirs to buy for ten friends with the condition that there are more bandanas than glasses, and one friend gets one souvenir (glasses or bandanas). Subject CS wrote down the glasses number, namely four and bandanas 6. After multiplying by the price, the money that must be paid to buy souvenirs for 10 of his friends is Rp. 128,000.

The subject can find the price of 1 pair of glasses and one bandana and get the correct answer. Then the subject can change the problem to other combinatoric problems, using the conclusions obtained from points *a*, *b*, and *c* to solve questions point *d*.

Subjects with a concrete sequential thinking style in the CS subject problem identification stage could write down what was known in the problem. When understanding the problem again, CS subjects could write down and mention what was asked in the questions presented. At the systematic writing stage, CS subjects could complete the questions until they found the correct answers with systematic and regular steps for solving them. Next, in changing other combinatoric problems in the problem, the subject can relate the conclusions obtained from previous answers to solve other combinatoric problems.

The study results are conducted by Muflihah et al. (2019), which stated that students with a concrete sequential thinking style solve questions in detail step by step to get the correct results.

## 2. Abstract Sequential Subject (AS)

Description written test completion on the student's combinatoric thinking process description test:

D1 = 2 kacamata + 5 bandana = 80.000  
 = 1 kacamata + 2 bandana = 36.000

Figure 6. AS subject answer

Figure 6 shows the AS subject description test answers results at the problem identification stage. The subject writes down what is known in the problem. The subject wrote a statement on the problem: two glasses and five bandanas cost 80,000, and 1 pair and two bandanas cost 36,000.

The subject can identify the problem. Through this understanding, the subject can identify what is known in the problem. Then the subject mentions the price of glasses and bandanas in the problem.

D2 = a. Nyatakanlah dalam bentuk variabel!  
 = b. Buatlah dalam bentuk matematika!  
 = c. Harga 1 kacamata dan 1 bandana?

Figure 7. AS subject answer

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In the second stage of problem understanding, AS subject wrote down what was asked in the question only at points *a*, *b*, and *c*. Only point *d* was not written down.

In the written answers and interviews, the subject stated the information asked in the questions correctly and precisely, in point *a*, namely, stating the glasses and bandanas in variable form. Point *b*, make the math equation. Point *c*, what is the price of 1 pair of glasses and one bandana? The subject did not write down point *d*, but after conducting the interview, the subject mentioned what was asked in point *d*.

|            |                                   |
|------------|-----------------------------------|
| $x_3 = a.$ | Kacamata = $x$                    |
|            | bandana = $y$                     |
| <hr/>      |                                   |
| $b.$       | $2x + 5y = 80.000$ ( $\times 1$ ) |
|            | $x + 2y = 36.000$ ( $\times 2$ )  |
| <hr/>      |                                   |
|            | $2x + 5y = 80.000$                |
|            | $2x + 4y = 72.000$                |
|            | $y = 8.000$                       |
| <hr/>      |                                   |
|            | $x + 2y = 36.000$                 |
|            | $x + 2 \cdot 8.000 = 36.000$      |
|            | $x + 16.000 = 36.000$             |
|            | $x = 36.000 - 16.000$             |
|            | $x = 20.000$                      |
| <hr/>      |                                   |
| $c.$       | 1 kacamata = $20.000$             |
|            | 1 bandana = $8.000$               |

Figure 8. AS subject answer

Then in the third stage, write systematically. At point *a*, the subject wrote down the glasses and bandana as variables. The AS subject, for example, used the variables  $x$  and  $y$ . At point *b*, the subject writes the SPLDV model equation by associating the variable at point *a*. Furthermore, students used a combined method to answer point *c*: elimination and substitution. Previously, the subject wrote down the method to

be used, namely by eliminating  $x$  to find  $y$  or  $a$  bandana, and the result was 8000 for the price of 1 bandana. Then, to find  $x$  or the price of glasses by substituting the  $y$  value into the equation, the price of 1 glass is 20000.

The subject makes variable examples for glasses and bandanas, and the subject can change them into the SPLDV. The subject explained how the steps were taken to find the price of 1 pair of glasses and  $a$  bandana by using elimination and substitution methods, and the answers were written in an orderly and systematic manner.

|   |  |
|---|--|
| $d.$  | $4x + 6y = 4 \cdot 20.000 + 6 \cdot 8.000$ |
|   | $= 80.000 + 48.000$                        |
|   | $2128.000$                                 |
|   | $150.000 - 128.000 = 22.000$               |
| Jadi, Dinda membeli 4 kacamata dan<br>6 bandana dengan sisa uang Rp 22.000 // |  |

Figure 9. AS subject answer

Figure 9 is the fourth stage of the combinatoric thinking process, the question is how many souvenirs to buy for ten friends with the condition that there are more bandanas than glasses and one friend gets one souvenir (glasses or bandanas). Subject AS wrote down the glasses number, namely four and bandanas 6. After multiplying by the price, the money that must be paid to buy souvenirs for 10 of his friends was IDR 128,000, and the remaining money that Dinda brought was 22,000.

Through written answers and interviews, the subject could find the price of 1 pair of glasses and one bandana and got the correct answer. Then the subject can change to another combinatoric problem, namely using the previous conclusions obtained from points *a*, *b*, and *c* to solve question point *d*.

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Subjects who have an abstract sequential thinking style (AS) at the problem identification stage, AS subjects can write down what is known in the problem correctly. When understanding the problem again, the subject can write down what is asked in the problem but is incomplete. However, during the interview, the subject could mention these deficiencies after rechecking. At the systematic writing stage, the AS subject carried out the solution by mentioning and writing down the steps for solving it with the correct answers. Next is the stage of changing other combinatorics problems. The AS subject can fulfill this stage correctly and regularly.

This is in line with Patimah & Murni (2017), which say that students with an abstract sequential thinking style tend to write incomplete information. This is because students with the AS thinking style prefer to think by analyzing information about regular events (Janah et al., 2021). Another finding, during the interview, the subject can clarify the lack of information, do it in detail, and give the correct answer based on the concept. This is consistent with the abstract sequential thinking style, namely conceptual thinking (Hernacki & De Porter, 2015).

## B. The Process of Student's Combinatoric Random Thinking Style

### 1. Abstract Random Subjects (AR)

Written completion description on the combinatoric thinking process description test (Figure 10). Figure 10 shows the AR subject's written test answers at the problem identification stage. It can be seen that the subject wrote down the information he knew; namely, in the first point, he wrote

down that the price of 2 glasses and five bandanas was IDR 80,000. On the second point, the subject wrote that the price of 1 pair of glasses and two bandanas was IDR 36,000.

Figure 10. AR subject answer

AR subjects can identify the problem and know the question's purpose. Through this understanding, the subject can determine what information is known about the problem.

Figure 11. AR subject answer

Furthermore, in the second stage of understanding the problem again, the subject has not entirely written down what was asked in the question. Subject C wrote down what was asked only in point a to point c.

From the written answers to the pictures and interviews, the subject did not entirely mention what was asked in the questions, and when asked during the interview, he only read the incomplete answer sheet. The subject only wrote down what was asked only up to point c. So, the subject has not fulfilled this stage.

Figure 12. AR subject answer

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Figure 12 is the fourth stage, namely changing other combinatorics problems. The subject makes the variable example first and changes the sentence in the question to the SPLDV. The subject wrote down the method or method to be used in solving the problem, namely the elimination method. The subject multiplied equation I by one and equation II by two, so the y value was 8,000.

From the written answers, the subject did not complete the answer. The subject did not explain the price of the glasses, so the subject did not fulfill this stage.

Subjects with an abstract random thinking style (AR) at the problem identification stage could write down what was known in the problem. However, concrete random subjects do not fulfill the following three stages: understanding the problem again. The writing stage is systematic. The subject only gets answers to only one problem and does not continue with the answers. The subject did not get an answer or conclusion. So that in the third and fourth stages of change, other combinatoric problems have not been fulfilled.

This is consistent with the characteristics of a concrete random thinking style, namely, working in a less structured manner (Hernacki & De

Porter, 2015). In addition, feelings can also further enhance or influence AA subject learning. In line with the research by Oktaviana & Abdillah (2021), it was said that students with the AA thinking style did the questions incompletely, and the steps in solving the problem were written incompletely.

## 2. Concrete Random Subjects (CR)

The following is the written completion description of the combinatoric thinking process description test:

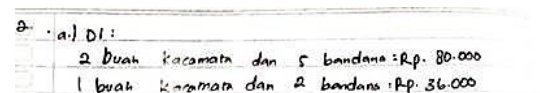


Figure 13. CR subject answer

Figure 13 is the problem identification stage. At this stage, the subject writes down what is known in the problem: the price of 2 glasses and five bandanas is Rp.80,000, and the price of 1 pair of glasses and two bandanas are Rp.36,000.

CR subject could know the problem and understand the question's purpose from the problem. Based on this understanding, the subject can determine the available information in the problem. The subject mentions the price of glasses and bandanas in the problem.

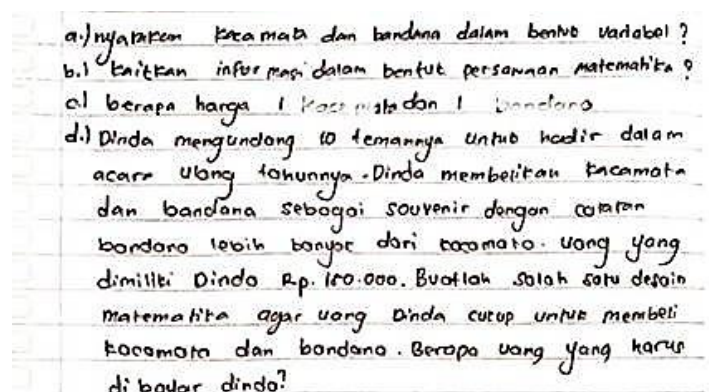


Figure 14. CR subject answer





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Table 1. Students' combinatoric of thinking style

| The Combinatoric Thinking Process Stage       | Indicators  | Subject Analysis Results |    |    |    |
|---|---|--------------------------|----|----|----|
|   |   | CS                       | AS | RA | CA |
| Problems Identification                       | Students can identify what is known in the questions presented                              | √                        | √  | √  | √  |
| Understanding the problem again               | Students can write down and mention what is asked in the questions correctly and completely | √                        | √  | √  | √  |
| Write systematically                          | Students can write mathematical models as well as regular and conceptual completion steps   | √                        | -  | -  | -  |
| Modification is another combinatorics problem | Students can relate the conclusions obtained to solve different problems.                   | √                        | √  | √  | -  |

### Discussion

Thinking styles can also be influenced by students' habits when participating in classroom learning and students' habits when studying at home (Angkarini, 2021). There are four student thinking styles: abstract sequential, concrete sequential, abstract random, and concrete random. Students who fall into the two sequential categories tend to have left-brain dominance, while students who think randomly tend to have right-brain dominance in solving problems. This study only took abstract thinking styles, sequential and random.

A. Putri et al. (2021) stated that students with an abstract sequential thinking style with abstract randomness are more creative in planning and solving problems. In combinatorial thinking, students are trained to combine ideas to solve their problems. Students can choose different ideas/formulas to solve problems, then produce different solving processes.

It all depends on the student's mindset in solving problems. People with an abstract thinking style can connect or make connections between mathematical concepts because they

have high reasoning abilities to combine all alternative solutions with logical thinking patterns.

### CONCLUSION AND RECOMMENDATION

Based on an analysis, subjects with concrete sequential (CS) and abstract sequential (AS) thinking styles achieve all combinatoric thinking processes indicators. Students with abstract random thinking style (RA) only reach the first stage indicators. Students with a concrete random thinking style (CR) can fulfill the thinking process indicators first, second, and third stages.

In a concrete sequential thinking style, students work on problems in detail, step by step. This is consistent with the concrete sequential thinking style characteristics, namely processing information step by step or in detail. Students with an abstract sequential thinking style work on questions according to the concept and write according to the abstract sequential thinking style, namely conceptual thinking. Meanwhile, students with random thinking styles, both concrete and abstract, solve problems randomly,

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and several concepts are not written down in detail.

It is hoped that the teacher will train students' thinking processes by getting used to giving problem-based questions. This can trigger students to work with systematic completion steps. For other researchers conducting similar research, studying students' thinking styles more deeply is better. This aims to make it easier for researchers to identify the indicators to be achieved. In addition, problems can be developed with other problems that are open-ended. The research subject should be used to determine the differences in each individual's thinking styles.

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