

Visual Students: How Their Representation in Problem Solving?

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ABSTRACT

Mathematics is abstract because mathematical objects or symbols do not exist in reality, it is almost impossible to access them without employing representations. Representations may aid in the transformation of physical models into abstract ideas or symbols. Students require representation to be able to describe, explain, and extend mathematical concepts by stressing the significance of form. However, it is unknown if visual students can grasp all elements of representation. The purpose of this research is to characterize students with visual learning styles' mathematical representation abilities while solving problems involving relations and functions. This study takes a qualitative approach. The researcher created the research instrument, which is already valid. This study was performed at SMP Negeri 1 Purwadadi, with a total of 34 students in class IX receiving material on relations and functions as research subjects. The researchers gathered data using a questionnaire that classified learners' learning styles (auditory, visual, and kinesthetic), as well as mathematical representation skill tests and interviews. Technical triangulation is used to do triangulation. The data were examined using the reduction, presentation, and verification phases. The study's findings indicated that visual students had greater mastery of mathematical representation abilities in the visual aspects, but lacked mastery in the verbal aspects.

Keywords: Learning style, Mathematics, Mathematical representation, Visual students.

1. INTRODUCTION

There are five standards in mathematics that explain the connection between mathematical comprehension and the mathematical skills that students must possess. The term "process standards" refers to the mathematical process through which students learn and apply information. The five process criteria are as follows: issue solving, evidence and reasoning, communication, connection, and representation [1]. The capacity to represent mathematical concepts mathematically is one of the mathematical skills that every student must acquire while studying mathematics, since the existence of representations in mathematics enables students to offer more concrete mathematical ideas [2]. Mathematical representation performs a crucial role in the learning of mathematics and is a skill that every student should possess. As an interpretation of their thoughts, representation is an expression of

mathematical concepts presented by students as a replacement for issue situations. It is intended to help students discover answers to the difficulties they encounter. A issue may be expressed visually, verbally, or mathematically [3], [4], [5]. According to Jones [6], there are many reasons for the significance of mathematical representation abilities, including the fact that they may be utilized to solve mathematical issues in addition to the skills students acquire for developing mathematical ideas and reasoning. Thus, mathematical representation abilities are required, in which students may describe, explain, and build on mathematical concepts while stressing the significance of form. Additionally, representation means the process of modeling concrete things in the real world into abstract concepts or symbols [7]. The capability of mathematical representation may aid students in improving skills such as constructing, comprehending, and expressing mathematical ideas [8], [9], [10], [11]. Student interpretation may take the shape of words or

vocal communication, writing, images, tables, graphs, tangible things, or mathematical symbols, among others.

Mathematical concepts or connections may be expressed in a variety of ways via the use of multiple representational styles, and knowing the links between representations is essential for mathematical concept interpretation. There are three aspects of mathematical representation, namely: (1) Visual representation in the form of diagrams, graphs, tables, and pictures; (2) Equations, symbolic or mathematical expressions; and (3) written words or text [12]. Of the three aspects, there are several indicators, Table 1 summarizes the indicators of mathematical representation.

Table 1. Indicators of mathematical representation

Mathematical Representation Aspects	Indicator
Verbal Representation	Write the procedures for solving mathematical issues.
	In writing, explain the answer to an issue using arguments or considerations.
Visual Representation	Create picture, graphs, or diagrams to aid in the clarification and solution of problems.
Symbolic Representation	Present a formula or equation.
	Calculate in order to solve issues.

Visual students are defined in this research as those that learn visually, specifically by looking at images or diagrams. Visual students exhibit a variety of features of mathematical representations, including a preference for visual solutions such as drawings, graphs, or diagrams when solving problems. Additionally, visual students are able to take steps toward developing and writing mathematical statements using verbal representations, and they are able to take efforts toward developing and writing mathematical sentences using symbolic representations.

Based on research that has been done by several researchers regarding the ability of mathematical representation either through learning approaches or in solving mathematical problems, it shows several categories or levels of mathematical representation abilities [13], [14]. These are based on research conducted by several researchers regarding the ability of mathematical representation, either through learning approaches or in solving mathematical problems. According to the study's findings, students were considered capable of high and medium mathematical representation if they met three criteria:

converting data or information from a problem to a table representation, solving problems involving mathematical expressions, and writing down steps for solving mathematics using words. However, students with low mathematical representation skills fulfilled just two indicators, namely solving problems using mathematical expressions and writing down the procedures necessary to solve them in simple words [13]. Mathematical representation ability is affected by a variety of variables, including the use of media, experience, and practice while solving mathematical issues [14]. According to several research, only a tiny percentage of students can properly solve math problems using representational skills, whereas the

majority fail to use their representational abilities, particularly visual representation abilities [15].

These are confirmed by field observations; according to the findings of interviews with teachers at the school, there are still a significant number of students who struggle to express their responses in terms (words, tables, graphs, diagrams, and even equations) in relation and function material. The differences in how each student represents the outcomes of his thinking are due to the fact that each student has unique thinking skills for absorbing, managing, and communicating information, which affects how individuals learn. This method of learning is more often referred to as a learning style. According to some of the reviewed literature, there are gap in our understanding of the ability of mathematical representation in terms of visual student learning styles to solve relation and function problems, researchers focus more on visual learning styles because they are more concerned with form and make extensive use of the sense of sight. Individuals who learn visually will see or imagine what is being spoken. Additionally, he has a great sensitivity to color, in addition to a solid grasp of creative concepts.

It's simply that individuals with visual learning styles often struggle with direct conversation since they are too receptive to sound, making verbal guidance difficult to follow and frequently misinterpreting words or speech [16]. Visual learners think in pictures and learn best in visual images. Sometimes, visual learners favour sitting in the front of the classroom. They also take descriptive notes over the material being presented, Students that choose a visual learning approach will do well on tasks such as recalling, comprehending, and linking facts and concepts [17]. This study should be conducted in order to ascertain the mathematical representation capacity of visual students. The study's findings may serve as a theoretical foundation for future research. For instance, studies on attempts to overcome the shortcomings of visual students, as well as the benefits of visual students discovered, may be utilized as new markers of non-visual students' success. Without this study, the representation of visual students and non-visual students would stagnate. As a result, this study is critical. The purpose of this research is to describe visual students' mathematical representation capacity while solving problems involving relation and function material. This study on mathematical representation is a subfield of educational research. As a result, this study is anticipated to provide new knowledge or information regarding the degree of mathematical representation achieved by visual students.

2. METHODS

2.1. Design

The purpose of this research is to demonstrate how students with visual learning styles may solve

problems involving relations and functions using their mathematical representation abilities. The results demonstrate that students' mathematical representation using a visual learning style without modification demonstrate a high degree of reasoning. That is, the researcher study will be descriptive in nature. Qualitative research is a kind of study that focuses on eliciting and comprehending meaning from a diverse collection of persons or groups of individuals affected by social issues [18].

2.2. Participants

The subjects of this research were SMP Negeri 1 Purwadadi students. Purposive sampling was employed to collect data. The participants for this study were chosen based on the requirements of the research, namely class IX students who had acquired the relation and function materials and had a visual learning style. Purposive sampling was used in this research to choose three students from the visual learning style group.

2.3. Instruments

The instruments utilized in this research were a questionnaire to classify learners' learning styles, a test of mathematical representation ability, and an interview guide. The questionnaire is designed to categorize students into three distinct learning styles (auditory, visual, kinesthetic). The test instrument, which is in the form of a description of relations and functions containing the three components of mathematical representation abilities, namely (Verbal, Visual, and Mathematical Expressions) [12]. Instrument has been validated by two materials experts in the fields of mathematics, mathematics education, and mathematical representation abilities research.



1. It is well-known that there are six students in a class who each have a favorite sport. Indar is a tennis enthusiast, Aziz is a badminton enthusiast, Nizar is a soccer enthusiast, Ochi is a basketball enthusiast, Fahri is a soccer enthusiast, and Anis is a basketball enthusiast. If the set $P = \{ \text{Indar, Aziz, Nizar, Ochi, Fahri, Anis} \}$ and the set $Q = \{ \text{Tennis, Bulu Tangkis, Sepak Bola, Basket} \}$, classify the relations as follows :

- a. Arrow diagrams
- b. Set of Consecutive Pairs; and
- c. Cartesian diagrams.

Figure 1 Test of mathematical representation ability 1



2. Kayla is celebrating her 17th Birthday. Then she takes her four friends: Vira, Oci, Dinar, and Ajeng to a dinner at the restaurant “D E W A T A”. chicken steak, beef steak, chicken satay, jinggo rice, and fried rice are all offered at the restaurant. It came out that each of them had selected a meal that was fairly diverse.

- Vira favorite foods are “fried rice and jinggo rice”, but she chose jinggo rice this time.
- Oci favorite foods are “chicken satay, beef steak, and chicken steak”, but she chose chicken steak this time.
- Dinar favorite foods are “jinggo rice and beef steak” but she chose beef steak this time.
- Ajeng favorite foods are “fried rice, jinggo rice, and chicken steak” but she chose fried rice this time.

Create three possible relations based on the scenario above. Then represent these relations using arrow diagrams, set of consecutive pairs, and Cartesian diagrams!

Descriptions:
Nasi Jinggo is a traditional Balinese fast meal served in tiny banana leaf servings

Figure 2 Test of mathematical representation ability 2

The validator advises students to utilize just two objects, each of which represents all elements of the mathematical representation and assesses students’ ability to learn visually. Additionally, in-person interviews with the subject are necessary to determine if the person properly performs the indications of mathematical representation ability. The two validators certify that these instruments are valid.

2.4. Data Collection Method

Tests, questionnaires, and interviews were used to gather data for this research. The questionnaire employed in this research is a student learning style questionnaire, which is intended to ascertain the students’ preferred method of learning, while the exam is designed to ascertain the students’ mathematical representation skills. The following is a test instrument for mathematical representation ability that is administered to the whole subject shown in Figure 1 and Figure 2.

2.5. Data Analysis

In this research, data analysis consists of data reduction, data display, and conclusion drafting. The data reduction step involves the identification of critical data required to accomplish the study goals. The reduced data is then used to characterize students’ mathematical representation skills in terms of three dimensions (Verbal, Visual, and Mathematical

Expressions) [12]. Finally, the researcher makes inferences from the data collected in order to address the study’s goals. Triangulation must be utilized in this study; the approach used is technical triangulation, which entails obtaining data from the same source using several ways and comparing the results acquired through the test and interview methods.

3. FINDING

This section contains information on three study subjects (A1, A2, and A3).

3. 1. Subject A1: Display and Analysis of Data

The answer sheet for A1 is shown in Figure 3. A1 answer the questions directly, without rewriting the material included in the questions. A1 responded to question 1 (a), by sketching an arrow diagram. In general, A1’s arrow diagram is accurate; nevertheless, A1 fails to document the connections established in presenting the arrow diagram. Additionally, A1 responded fully to question 1 (b), since A1 changed the sentences in the issue to create a collection of consecutive pairs set. It’s simply that A1 misspells the set of consecutive pairs: (Aziz Badminton), (Indar Tennis), ...

While it should read:

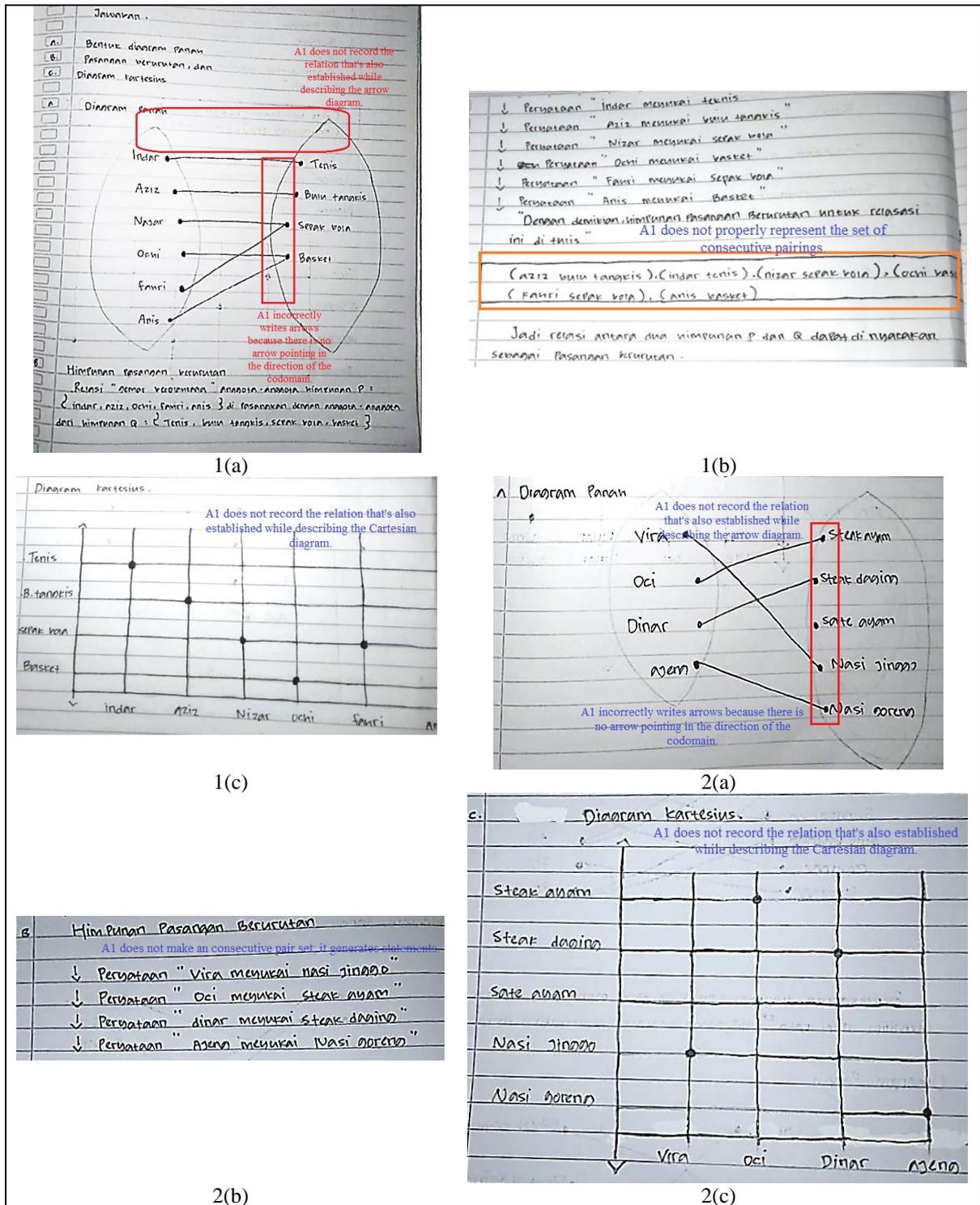


Figure 3 AI answer sheet.

{(Aziz, Badminton), (Indar, Tennis),...}. In response to question 1 (c), AI responded by describing a Cartesian diagram without specifying the connections that were included into the Cartesian diagram.

Additionally, while attempting to answer question number 2, AI seems to be perplexed in identifying the three relations that may be derived from the issue. AI generates an arrow diagram without recording the connections that are formed. Additionally, AI writes just a few statements from the issue when creating a

collection of consecutive pairings, such as “Vira like Jinggo rice”, “Oci like chicken steak”, etc. in response to question 2, A1 creates a Cartesian diagram without recording the connections that are included in the Cartesian diagram.

This is validated by the following findings from interviews with subject A1:

- R : *"What information did you get from question number one? What question was posed?"*
- A1 : *"There are six students in one class who like a variety of sports. For instance, Indar is a tennis enthusiast, Aziz is a badminton enthusiast, Nizar is a soccer enthusiast, Ochi is a basketball enthusiast, Fahri is a soccer enthusiast, and Anis is a basketball enthusiast. We are tasked with creating arrow diagrams, consecutive pairings, and Cartesian diagrams"*
- R : *"Explain the significance of the response you provided. Is the response you provided, correct?"* (While displaying response 1 (a))
- A1 : *"In response to question 1a, you were requested to create an arrow diagram; therefore, I created one in which the left arrow represents the student's name and the right arrow represents sports; you just need to link them, I believe my response is right."*
- R : *"Explain the significance of the response you provided. Is the response you provided, correct?"* (While displaying responses 1 (b) and 1 (c))
- A1 : *"Problem 1b entails the creation of a sequence of consecutive pairings. As a result, I began by writing down the information in the new issue in order to create a collection of consecutive pairings. Problem 1c, you were requested to create a Cartesian diagram. I created a horizontal line for the student's name and a vertical line for the sport's name. I believe my response is right."*
- R : *"What information did you get from inquiry number two?"*
- A1 : *"Kayla takes four of her pals to a restaurant; each of them has a distinct cuisine preference. Vira is a fan of Jinggo rice, Oci is a fan of chicken steak, Dinar is a fan of beef steak, and Ajeng is a fan of fried rice. The inquiry is intended to establish a connection."*

- R : *"Explain the significance of the response you provided. Is the response you provided correct?"* (While displaying response 2 (a))
- A1 : *"With regards to 2a, you were requested to create an arrow diagram; thus, I created one as follows for the person on the left; the name of the person on the right corresponds to the name of your favorite dish; just link it. I believe that is accurate."*
- R : *"Explain the significance of the response you provided. Is the response you provided, correct?"* (While displaying responses 2 (b) and 2 (c))
- A1 : *"Since 2b was requested to create a collection of consecutive pairings, I did so base on what I observed in the issue." 2c was requested to create a Cartesian diagram, so I created a horizontal line representing the person's name and a vertical line representing his favorite cuisine. Certainly correct"*
- R : *"Which do you think is more interesting? solve the problem by illustration, words, or symbols?"*
- A1 : *Illustrating a solution to a problem"
"Because it is more enjoyable and simpler to comprehend."*

According to the findings of these interviews, subject A1 generally understood the questions well, as shown by his detailed responses when the researcher inquired about the information acquired from questions 1 and 2. Meanwhile, A1 did not comprehend how to put the kind of connection into the arrow diagram because, in responding to questions 1 (a) and 2 (a), A1 did not describe the type of relationship that was included into the arrow design. A1 responded adequately to the interview for number 1 (b), indicating that A1 knew enough about topic 1 (b). A1 also does not comprehend how to put the kind of connection into a Cartesian diagram since, in responding to questions 1 (c) and 2 (c), A1 fails to describe how the Cartesian diagram is constructed. A1 responded to the researcher's inquiry about question 2 (b) with a less-than-clear reply such as "2b was requested to create a group of consecutive pairings, therefore I created it that way based on what I observed in the question," implying that A1 did not comprehend question 2 (b). According to A1's responses to the researcher's last question, A1 is a visual student with visual representation qualities.

3. 2. Subject A2: Display and Analysis of Data

Figure 4 is the answer sheet from A2. A2 immediately answered the question without rewriting the information on the question, A2 also seemed to still have difficulty understanding the question and providing the intended answer. Look at the answers given. A2 answers questions number 1 and 2 outside the relation and function material. In question number 1, A2 answered: Football = $18/60 \times 100\% = 20\%$ and Tennis = $6/60 \times 100\% = 20\%$. Based on the answers given by A2, it can be said that A2's mathematical representation ability is low. Students in the low category cannot look at the problems given properly, then the method of completion and calculations are not correct [18]. This is also based on the fact that A2 does not answer questions number 1 and 2 by drawing arrow diagrams, Cartesian diagrams or making sets of consecutive pair.

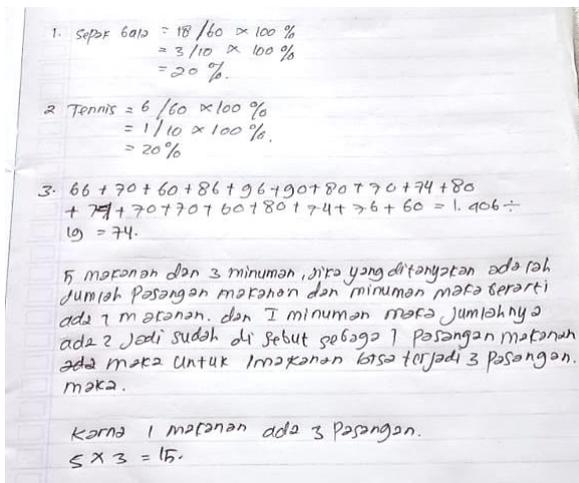


Figure 4 A2 answer sheet.

This is validated by the following findings from interviews with subject A2:

- R : "What information did you get from question number one? What question was posed?"
- A2 : "Sports-obsessed students." Establish a relationship"
- R : "What information did you get from inquiry number two? What question was posed?"
- A2 : "Kayla treats her friends to meals. Establish a relationship"
- R : "Explain the significance of the response you provided. Is the response you provided, correct?" (When displaying the response sheet)

- A2 : "Calculating relations and deriving conclusions from them. Already accurate"
- R : "Which do you think is more interesting? solve the problem by illustration, words, or symbols?"
- A2 : "Using words to solve an issue"
- R : "How did you come to choose this?"

According to the interview findings, subject A2 generally does not comprehend the question; when the researcher inquires about the information gathered on the topic, A2 provides an incomplete response. Additionally, when questioned about the answer sheet, A2 provided erroneous responses such as "calculated relations and derived conclusions from relations." This indicates that A2 is still having difficulties comprehending the questions and giving the corresponding responses. According to A2's responses to the researcher's last question, A2 is a visual student with verbal representation qualities.

3.3. Subject A3: Display and Analysis of Data

The answer sheet from A3 is shown in Figure 5. A3 does not modify the information provided in question 1 (a). A3 automatically generates an arrow diagram without recording the connections that are established. Additionally, in question 1 (b), A3 properly writes the set of consecutive pairs, since the set of consecutive pairs starts with curly brackets ({}). In response to question 1 (c), A3 responded by describing a Cartesian diagram without specifying the connections that were included into the Cartesian diagram.

Additionally, when students work on issue 2 subject A3, they seem to be perplexed about identifying the three relations that may be derived from the problem. A3 generates an arrow diagram without recording the connections that are formed. While A3 has written the set of consecutive pairs properly, when it comes to creating the Cartesian diagram in problem number 2, A3 creates the Cartesian diagram without recording the relations that are included in the Cartesian diagram.

This is validated by the following findings from interviews with subject A3:

- R : "What information did you get from question number one? What question was posed?"

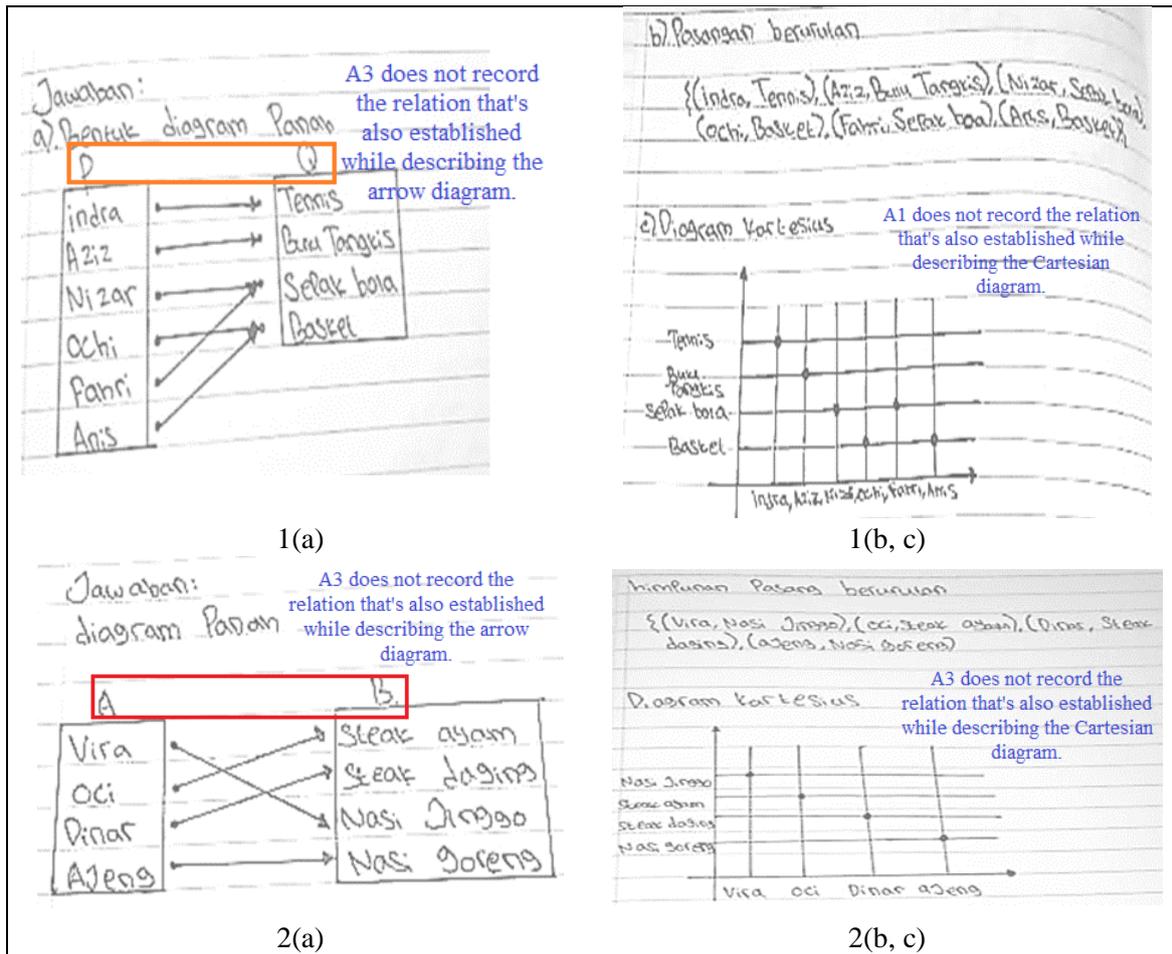


Figure 5 A3 answer sheet

- A3 : "In a single class, there are six individuals with diverse interests. For instance, Indra is a tennis enthusiast, Aziz is a badminton enthusiast, Nizar is a soccer enthusiast, Ochi is a basketball enthusiast, Fahri is a soccer enthusiast, and Anis is a basketball enthusiast. Individuals were instructed to create relations using arrow diagrams, consecutive pairs, and Cartesian diagrams"
- R : "Explain the significance of the response you provided. Is the response you provided correct?" (while displaying response 1 (a))
- A3 : "So, it is clear from the question that set P is for the student's name and set Q is for the student's preferred sport. Therefore, just transform it into an arrow diagram and link it with an arrow. I believe that is accurate."
- R : "Explain the significance of the response you provided. Is the response you provided, correct?" (While displaying responses 1 (b) and 1 (c))
- A3 : "Number 1 b creates a collection of consecutive pairs of data in the problem, which is subsequently converted to a set of consecutive pairs. If number 1 c is a Cartesian diagram, the horizontal axis corresponds to the student's name; if the vertical axis corresponds to the sport's name, remain in the simply match it. I believe that is accurate."
- R : "What information did you get from question number two? What question was posed?"
- A3 : "So Kayla treats four of her pals, each with a unique meal. Vira placed an order for jinggo rice, Oci placed an order for chicken steak, Dinar placed an order for beef steak, and Ajeng placed an order for fried rice. Asked to create diagrams of relations using arrow diagrams, consecutive pairs, and Cartesian diagrams."

- R : *"Explain the significance of the response you provided. Is the response you provided, correct?" (While displaying response 2 (a))*
- A3 : *"So, all you have to do is convert the information in the question into an arrow diagram and then link it with arrows, where A represents the person's name and B represents the meal he ordered. I believe that is accurate."*
- R : *"Explain the significance of the response you provided. Is the response you provided, correct?" (While displaying responses 2 (b) and 2 (c))*
- A3 : *"The number 2 b enters a consecutive pair of data into the issue, and then creates a collection of consecutive pairs. If the 2 c is in the shape of a Cartesian diagrams, the horizontal axis represents the person's name and the vertical axis represents the food's name; just match them up. I believe that is accurate."*
- R : *"Which do you think is more interesting? solve the problem by illustration, words, or symbols?"*
- A3 : *"Illustrating a solution to a problem"*
- R : *"How did you come to choose this?"*
- A3 : *"it's more enjoyable, but it's also more understandable"*

According to the findings of these interviews, the subject of A3 generally understood the questions well, as shown by A3's detailed responses when the researcher inquired about the information acquired from questions 1 and 2. Meanwhile, A3 did not comprehend how to put the kind of connection into the arrow diagram because, in responding to questions 1 (a) and 2 (a), A3 did not explain how the relations were created in the arrow diagram, but rather described the processes. A3 responded adequately to the interview for number 1 (b), indicating that A3 knew enough about topic 1 (b). A3 also does not comprehend how to put the kind of connection into a Cartesian diagram since, in responding to questions 1 (c) and 2 (c), A3 fails to describe how the Cartesian diagram is constructed. A3 responded to the researcher's inquiries concerning issue 2 (b) with a reasonably good response, indicating that A3 comprehended the subject enough. According to A3's responses to the researcher's last question, A3 is a visual learner with visual representation qualities.

4. DISCUSSION

The author's research subjects in this study are those with visual learning styles. Subjects A1, A2, and

A3 are considered visual students because they exhibit all of the indicators of visual learning styles, including the following: (1) visual learning means that students can more easily comprehend the lesson by observing the teacher's body language/facial expressions, reading, and writing; (2) strong grasp of position, shape, number, and color; (3) neat and orderly; (4) not sloppy; and (5) difficult to accept verbal instructions [19]. In terms of the indicators of mathematical representation in Table 1, the visual students in this research are those who exhibit a variety of mathematical representation characteristics, including visual representation, in which they prefer to solve problems using images, graphs, or diagrams. Additionally, visual students are able to take steps toward developing and writing mathematical statements using verbal representations, and they are able to take efforts toward developing and writing mathematical sentences using symbolic representations.

In aspects of verbal representation, based on the results of the analysis described previously, it can be concluded that the three research subjects did not master because they did not rewrite the information contained in the questions when answering them, and when answering the questions, the three research subjects concentrated exclusively on the answers without providing explanations. or the rationale for the chosen response. In terms of verbal representation, based on the results of the three research subjects' work, it can be concluded that they did not master because the three research subjects did not rewrite the information contained in the questions and instead focused exclusively on the answers without providing explanations or reasons. The three study participants did not jot down the procedures necessary to resolve the issue. This is due to a variety of reasons, including a lack of comprehension of the problems at stake [20]. The low level of verbal representation may also be explained by the fact that the majority of students have difficulties putting their thoughts or responses into words (verbal) [20]. This issue may be addressed by providing contextual challenges that are at or below the level of the student's competence and gradually raising the complexity of the task. Thus, mathematics will be more engaging and meaningful for students if it begins with something real and relevant to their experience [21]. Additionally, it can alleviate students' difficulty in verbalizing their interpretations.

In terms of visual representation, two of the three research subjects have a firm grasp on aspects of verbal representation. Because subjects A1 and A3 are capable of accurately describing arrows and Cartesian diagrams. It is just that one study subject has not yet

grasped this element of visual representation, since subject A2 did not respond to the query with an arrow diagram or a Cartesian diagram. This can occur as a result of the subject's inability to visually represent information about the problem [22]. This factor can be overcome by providing students with opportunities to practice solving mathematical problems [23], This enables students to express an issue using their own ideas or concepts, rather of relying only on a representation provided by the teacher.

Additionally, two of the three study participants have not grasped the symbolic representation component. Because subject A1 is still unable to write the set of consecutive pairs accurately, subject A2 fails to write the set of consecutive pairs properly while completing the issue, but subject A3 successfully writes the set of consecutive pairs. This may occur as a result of the individual becoming less concerned with writing symbols. This factor can be overcome by requiring students to perform exercises involving the construction of symbolic representations, which will enable them to comprehend and apply concepts effectively and flexibly when solving mathematical problems [24].

5. CONCLUSION

The researcher concludes that mathematical representation has three aspects (verbal, visual, and symbolic). First, visual students' skills in verbal representation are lacking because they lack mastery of mathematical representation indicators such as (1) solving mathematical problems using words; and (2) explaining an issue in writing using reasons or considerations. Second, the ability of visual students in the aspect of visual representation may be considered to be nearly mastered or in the intermediate category, since visual students (A1, A3) can create arrow diagrams, and Cartesian diagrams in solving issues. As with subject A2, the subject did not answer the question by describing an arrow diagram or a Cartesian diagram. Third, visual students' ability in the symbolic representation aspect can be said to be quite mastered or sufficient, because visual students (A3) correctly answer questions by writing the set of consecutive pairs, whereas the subject (A1) does not correctly write the set of consecutive pairs, and the subject (A2) does not correctly write down the set of consecutive pairs in solving.

In general, the capacity of students with visual learning styles to master mathematical representation is in the visual aspect (images), whereas the verbal aspect is the least mastered. The findings of this study may serve as a theoretical foundation for future

research on the impact of learning styles, visual thinking, and etc. Additional study methods are required, such as quantifying students' visual representation abilities using quantitative designs.

AUTHOR'S CONTRIBUTIONS

The author had an active role in the composition of this essay. Additionally, the writers gather and analyze data in real time, as well as conduct a comprehensive assessment of the current literature, which is then put into the form of this paper.

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