Exploring a Male Middle School Student's Understanding of the Concept of Function

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Function is central in mathematical learning. Therefore, understanding the concept of function is important for students to comprehend other broader mathematical concepts. This study aims to explore the understanding of the concept of function of a male student, with a moderate mathematical ability, using a qualitative approach. To obtain such a student, the researchers grouped students by gender using a questionnaire adopted from The BEM Sex Role Inventory (BSRI). Each student answered the questionnaire five times to ensure data consistency. Once the appropriate student was selected, an interview was conducted in order to collect data. The interview involved questioning the student about the concept of function. The results show that there are unique findings in the category of summarizing, inferring, and comparing.

Keywords: concept of function, male student, middle school, understanding

INTRODUCTION

Having a good understanding is one of the traits that is needed by students to master lessons at school. Newton (2000) stated that understanding is an indicator of the quality of learning. Some studies show that understanding can help students carry out more complex activities, such as looking for examples and comparable examples to determine the truth (Conner, Wilson, and Kim 2011), solving mathematical problems (Hernández, Perdomo-Díaz, and Camacho-Machín 2019), and connecting a concept with other concepts (Tripathi 2008). Furthermore, based on Bloom's taxonomy, understanding is at level C2, which is the foundation for higher levels in the taxonomy, because remembering (level C1) alone is not enough. Understanding must be proficient so that the remaining four levels of Bloom's taxonomy can be established efficiently.

Understanding is a cognitive activity that includes seven categories, namely: interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (Mayer 2002). Interpreting is when one is able to change information from one representation to another, such as transforming an

image into a word, a word into an image, a number into a word, or a word into a number. Exemplifying refers to ones's ability to find examples of a concept or a general principle. Classifying is when one is able to determine an example belonging to a certain category. Summarizing is the ability to make a brief statement that represents the information given. Inferring is when one is able to draw logical conclusions from the information presented. Comparing is when one is able to find similarities and differences between two or more objects, events, ideas, problems, or situations. Lastly, explaining is when one is able to mentally build a causal model of an event. These seven categories are fundamental for students to understand a mathematical concept, especially functions.

It is important to teach the concept of function because it is the basic concept of more complex mathematical concepts such as limit, integral, and differential. Concurrently, Ponce (2007) states that function is a central topic in mathematics learning that has an impact on the future success of students. In Indonesia, the concept of function is first taught in the second grade of middle school. The application of the seven categories of understanding in terms of the basic concept of function is presented in Table 1.

TABLE 1
THE APPLICATION OF THE SEVEN CATEGORIES OF UNDERSTANDING TO THE BASIC CONCEPT OF FUNCTION

No	Categories of Understanding	Function
1	Interpreting	•Represent the information given in the form of arrow diagrams, ordered pairs, and Cartesian coordinates.
2	Exemplifying	•Create an example of a function and a non-function relation in the form of an arrow diagram, an ordered pair, and a Cartesian coordinate.
3	Classifying	•Categorize an example of a function and a non-function relation in the form of an arrow diagram, an ordered pair, and a Cartesian coordinate.
4	Summarizing	•Mention the functional relational characteristics of set A to set B in the form of an arrow diagram, ordered pairs and Cartesian coordinates.
5	Inferring	•Sum up the definition of function.
6	Comparing	•Determine the difference of a relation that is functional and not functional.
7	Explaining	•Explain whether a relation is a function or not if changes are made to the initial relation.

A students understanding of a concept is influenced by several factors, one of which is gender. Some notions of gender, according to experts, include social categories built on biological and personality differences (Helgeson 2016; Leinbach, Hort, and Fagot 1997). Furthermore, Santrock (2016) explained that gender difference is divided into three categories, namely: physical/sex difference (male and female), personality difference (masculine, feminine, and androgyny), and social status (men are more powerful than women). The gender being referred to in this study is based on sex, with males that have masculine traits.

Several studies have discussed the relationship between understanding and gender (Hyde, Fennema, and Lamon 1990; Picciarelli et al. 1995; Zohar and Gershikov 2008). The results of these studies showed that men excel at solving problems because they tend to use more abstract strategies that reflect conceptual understanding (Fennema et al. 1998). Moreover, Walkerdine (1998) stated that men in general tend to be refractory; they enjoy making new rules that break the actual concept. However, these studies did not describe the understanding based on the Mayer category. Therefore, the present study hopes to describe understanding of the concept of function (which contains seven Mayer categories) in middle school male students. Based on the description above, this research statement is presented as:
-     What is the understanding of the concept of function in junior high male students?

METHODS

The present study is exploratory and followed a qualitative approach. This study aims to determine the understanding of the concept of function in middle school male students. The data obtained were based on the students answers from a test about the concept of function conducted through interviews. The participant of this research project was a male middle school student in the 8th grade who had studied the concept of function. The process of selecting this participant began by selecting a group of male junior high school students who had studied the concept of function. The researchers then grouped the students based on gender (Monto 1993) using the BSRI gender questionnaire provided online. The questionnaire was answered five times by each student to ensure the consistency of the masculine male students group. After that, one male student with moderate mathematical ability was selected.

The data collection instruments were the gender questionnaire, the test regarding the concept of function, and then an interview. The majority of the data collected for this study was obtained by the interview. The interviews were semi-structured in which the questions given were open-ended. Because this study took place during the Covid-19 pandemic, the interviews were conducted using the Google Meet application with a time range of 45-60 minutes in each interview session. The process of data analysis conducted in this study was as follows: 1) categorization/ classification of data, 2) data reduction, 3) data presentation, 4) data interpretation, and 5) conclusion. To confirm the findings, we applied data triangulation involving time; we conducted interviews using the same questions at different times to determine if the answers given by the students were consistent.

RESULTS

This paper only presents the findings that are unique in the Mayer's Understanding categories, namely summarizing (question 4A, 4B, 4C), inferring (question 5), and comparing (question 6).

The Summarizing Category

In this category, the student was asked to discuss the characteristics of the relationship from set A to set B in the form of an arrow diagram, ordered pairs, and Cartesian coordinates, all of which are functions.

Arrow Diagram

Question 4A: The student was asked to discuss the relational characteristics of set A to set B in the form of an arrow diagram. Two examples of arrow diagrams were given below. The students answers and interview transcripts, based on question 4A are listed in Table 2.

FIGURE 1
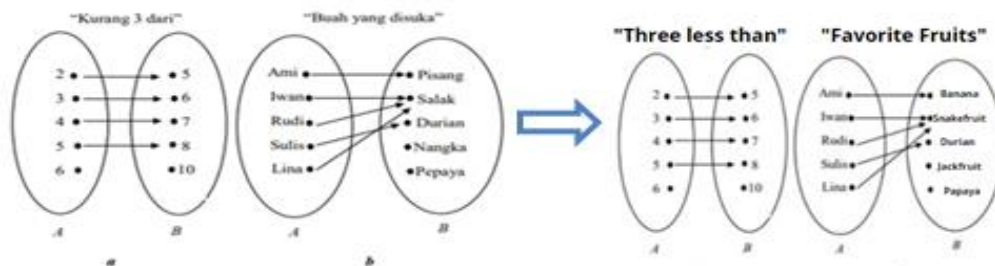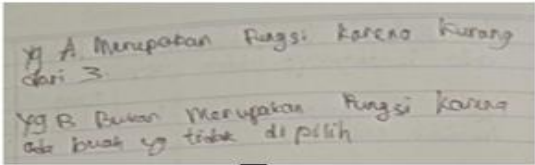**TWO EXAMPLES OF ARROW DIAGRAMS IN SUMMARIZING CATEGORY**

TABLE 2
THE ANSWERS AND INTERVIEW TRANSCRIPTS BASED ON QUESTION 4A

Summarizing the arrow diagram which is a function	Student interview results
A is a function because it's less than 3 B is not a function because there is a fruit not chosen	Researcher: Which of these two arrow diagrams do you think represents a function? Student: It is A. Researcher: Based on the arrow diagram, try to specify the characteristics of the function. Student: Because it is less than three. 5-3=2; 6-3=3; 7-3=4; 8-3=5. Researcher: Are there any more characteristics of a function that you want to convey? Student: No.
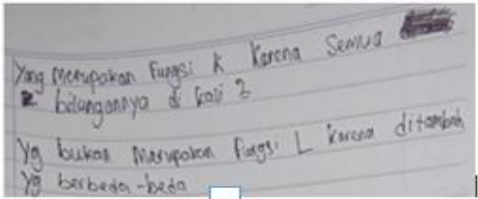
The student was incorrect in summarizing the characteristics of the relationship in the form of a functional arrow diagram. He did mention the characteristics of the arrow diagram, namely the codomain members who had selected pairs in the domain in accordance with the given relation (5-3=2; 6-3=3; 7-3 =4; 8-3=5), and the codomain members whose relations were incompatible and did not have pairs in the domain (10 is not paired with 6). This was clearly not in accordance with the characteristics of the arrow diagram which is a function (Table 2).

Ordered Pairs
Question 4B: The student was asked to discuss the characteristics of functional relations between set K and set L in the form of ordered pairs. The following two examples of ordered pairs were provided below. The students answers and interview transcripts based on question 4B are listed in Table 3.

$$a. \ K = \{(2,1), (4,2), (6,3), (8,4), (10,5), (12,6), (14,7), (16,8)\}$$
$$b. \ L = \{(2,1), (3,1), (3,2), (4,3), (5,3), (5,4), (6,5), (7,6)\}$$

TABLE 3
THE ANSWERS AND INTERVIEW TRANSCRIPTS BASED ON QUESTION 4B

Summarizing ordered pairs that are functions	Student interview results
K is a function because all the numbers are multiplied by 2 L is not a function because it is added with different numbers	Researcher: Which of the two ordered pairs do you think represents a function? Student: The K one. Researcher: Based on the ordered pair, try to specify the characteristics of the function. Student: The characteristics are because all the numbers are multiplied by two. 1x2=2; 2x2=4; 3x2=6; 4x2=8; 5x2=10; 6x2=12; 7x2=14; 8x2=16. Researcher: Are there any more functional features that you know of? Student: No.

The student was incorrect in summarizing the characteristics of the relationship in the functional ordered pair. He mentioned that the characteristics of the functional ordered pair was that each member of

a codomain was paired to a member of a domain by a certain relation, where the members of the codomain are multiplied by a certain number (1x2=2; 2x2 = 4; 3x2 = 6; 4x2=8; 5x2 =10; 6x2=12; 7x2 =14; 8x2 =16). This observation is not in accordance with the characteristics of the functional ordered pair (Table 3).

Cartesian Coordinates

Question 4C: The student was asked to discuss the relational characteristics of set A to set B in the form of functional Cartesian coordinates. The two examples of Cartesian coordinates provided are shown below. The students answers and interview transcripts based on question 4C are listed in Table 4.

FIGURE 2
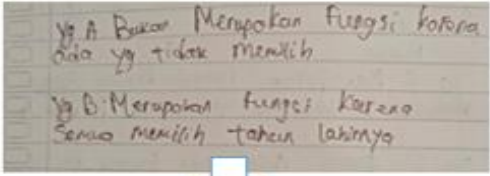**THE TWO EXAMPLES OF CARTESIAN COORDINATES IN SUMMARIZING CATEGORY**
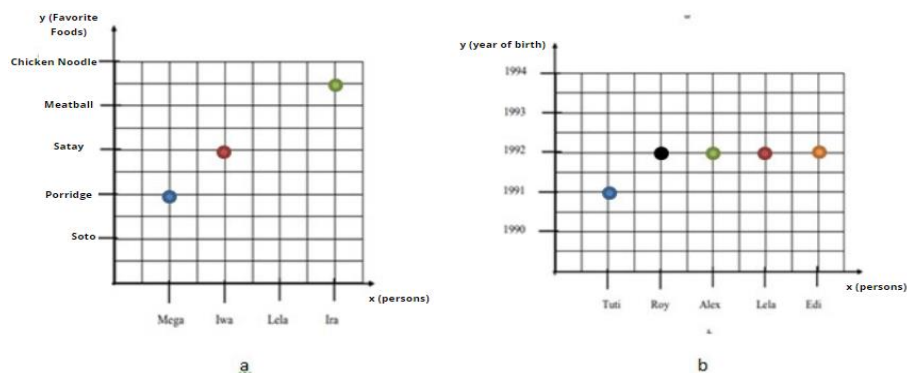
TABLE 4
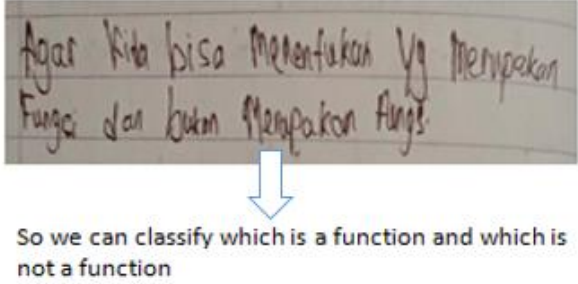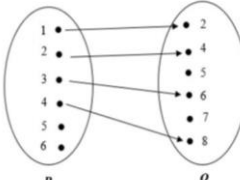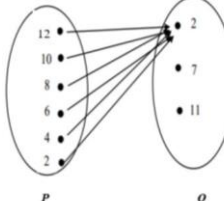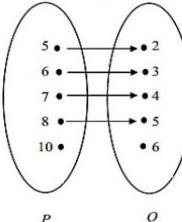**ANSWERS AND INTERVIEW TRANSCRIPTS BASED ON QUESTION 4C**
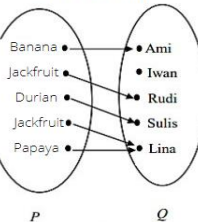
Summarizing Cartesian coordinates that are a	Student interview results
  A is not a function because there are some did not choosing. B is a function because all choose their birth year	Researcher: Which of these two Cartesian coordinates do you think is a function? Student: The b one. Researcher: Based on the Cartesian coordinates, try to specify the characteristics of the function. Student: Because everyone chooses their year of birth. Tuti, Roy, Alex, Lela, Edi. Tuti was born in 1991. Roy, Alex, Lela, Edi chose 1992. Researcher: Are there any more characteristics of a function that you know of? Student: No.

The student was incorrect in summarizing the characteristics of the relationships in the functional Cartesian coordinates. The student discussed that the characteristics of the functional Cartesius coordinates was that each member of the domain had chosen a partner in the codomain (Tuti chose 1991, Roy chose 1992, Alex chose 1992, Lela chose 1992, and Edi chose 1992). However, his interpretation is incompatible with the features of functional Cartesian coordinates (Table 4).

Inferring Category

In this category, the student determined the definition of function. The question proposed to the student in this category was as follows: Question 5: Based on these characteristics, what do you think the function of set P to set Q is? The answers and interview transcripts based on question 5 are listed in Table 5.

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TABLE 5
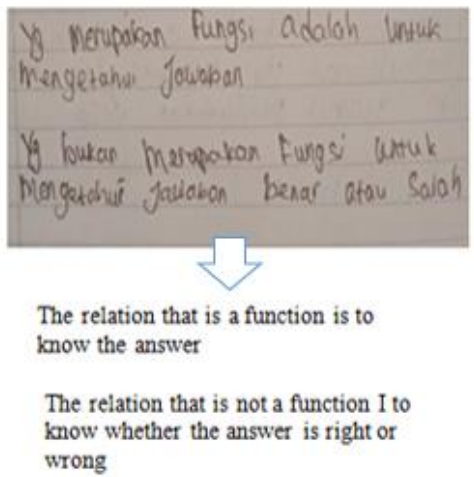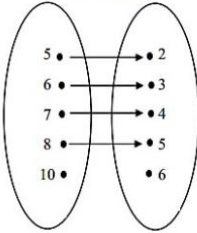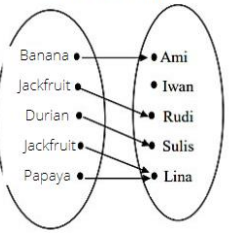**THE ANSWERS AND INTERVIEW TRANSCRIPTS BASED ON QUESTION 5**

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Function inferring	Student interview results
  So we can classify which is a function and which is not a function	Researcher: Based on the characteristics of the function you mentioned in question number 4A, 4B, 4C try to mention the definition of the function, Student: See the previous example, ma'am. (the student asked the researcher to show question 3 he had worked on). B is a function because it chooses a multiple of two and A is not a function because there are numbers that are not chosen. Numbers 5,6,and 7 are not selected (5 and 6 in set P and 5 and 7 inset Q) (the student concluded that the relation is a function or not a function through pictures) (Researcher shows question number 3) A is a function because it is more than 3 and B is not a function because jackfruit and papaya chose Lina, and Iwan was not chosen. Researcher: Do you think there are other definitions of function besides the ones you mentioned? Student: No.

The student did not conclude the correct definition of function. Furthermore, the student asked the researcher to refer to the problems he had worked on previously in the classifying and summarizing categories. Based on the picture, the student concluded that the functional relation must be in accordance with the relationship provided. The relation was not a function if there are domain members who do not choose and codomain members who are not chosen.

Comparing Category

The student was asked to determine the difference between a functional and non-functional relation. The question proposed to the student in this category was as follows Question 6: What do you think the difference is between the functional relation of set P to set Q and the non-functional relation of set P to set Q? The answers and interview transcripts based on question 6 are shown in Table 6.

TABLE 6
THE ANSWERS AND INTERVIEW TRANSCRIPTS BASED ON QUESTION 6

Comparing functions and non-functions	Student interview results
  The relation that is a function is to know the answer The relation that is not a function I to know whether the answer is right or wrong	Researcher: Based on the characteristics of the function that you mentioned in question number 4A, 4B, 4C, what do you think the difference between a functional and non-functional relation is? Student: The functional relation is to know the answer and the non-functional relation is to know the right or wrong answer. Researcher: Can you explain more? Student: It means the one that is not a function is to know whether the answer is right or wrong. A is a function. It is used to determine the answer: 5 selects 2; 6 selects 3; 7 selects 4; 8 selects 5. B is not a function. To know whether the answer is right or wrong means: you should select one favorite fruit. Lina chose two favorite fruits, namely, jackfruit and papaya. Researcher: Is there anything else you know about the difference in relation that is a function and that is not a function? Student: No.

The student was unable to determine the differences between function and non-function. He stated that a relation is a function if there are domain members linked to codomain members in accordance with the

relationship given. Whereas, to find out which relation is not a function, the student explained that the relation must meet the given relation, but the members of the codomain must not be linked to two members of the domain (Lina chooses two favorites, namely jackfruit and papaya).

DISCUSSION

Based on the interview answers of the student with regards to the summarizing category, our results show that the subject (male student) was unable to correctly summarize the characteristics of functional relationships in the form of arrow diagrams, ordered pairs, or Cartesian coordinates. Our results are not consistent with data from a study by Khanal (2017), that stated that boys are able to summarize mathematical concepts through the charts and graphs presented.

In the inferring category, our results showed that the student was unable to deduce the function from set A to set B correctly. The student explained that the functional relation from set A to set B, must be in accordance with the relationship provided, while the non-functional relation from set A to set B occurs if there are domain members who do not choose and codomain members who are not selected. Our observation was in contrast to the results of other studies which stated that male students were able to make conclusions based on the information provided (Dickhäuser and Meyer, 2006; Mawaddah et al. 2018; Zhu 2007). In this study, the male student was not able to make clear conclusions about function deficiency.

In the comparing category, Khanal (2017) states that men are able to make comparisons through examples. However, our results showed the opposite; the student was not able to compare a functional relation from set P to set Q with a non-function relation, and therefore could not identify the difference between them.

CONCLUSION

Based on the explanation above, it is concluded that the male junior high school student does not understand the concept of function in several categories of Mayer's model of understanding, namely in summarizing, inferring, and comparing. This study only described the understanding of the concept of function of one male student. Therefore, future studies should be conducted to describe student's understanding based on other factors, such as cognitive and learning styles, etc. The material used to explore the concept of function in this study is the same material that is used to introduce 8th grade middle school students to the concept of function. Therefore, it is necessary to conduct studies which focus on function in higher grades, considering that function is the basis of more complex mathematics, such as limit, integral, and differential.

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