Research Article

Analysis of Students' Mathematical Connection Ability in Solving Task of Function

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Abstract.
This study aims to analyze the student's mathematical connection ability in topic of function, by using a descriptive qualitative analysis. Twenty-five students of grade 10 from one of the favorite schools in Sukabumi, West Java participated in the study. Data were collected by conducting instruments mathematical connection ability test and a short interview. The result showed that students' mathematical connections were still in the low category with an average score of 43. Recommendations for future research are suggested, especially in improving students' ability in mathematical connection by applying learning methods that will enhance their skills.

Keywords: function, mathematical connection ability, solving task.

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1. INTRODUCTION

Mathematics had been considered as an important knowledge. According to educational system of this country, mathematics is a mandatory subject that students must learn in primary and secondary school level. By learning mathematics, students are expected to develop their problem solving, logical and systematical thinking skills in order to become individual with higher order thinking skills. For instance, students can apply mathematics in everyday life which is seen as a core goal of learning mathematics [1]. Based on its characteristics, mathematics is not a set of isolated topics but rather a web of closely connected ideas [2]. The ideas and concepts in mathematics are connected and integrated each other. We can use a particular concept of strands in mathematics to solve problems that come from another strands. That is why, Hiebert and Carpenter said that making connections between mathematical ideas is essential to understand mathematics [3]. Thus, an ability to connect mathematical ideas is very important in learning mathematics. This ability is known as mathematical connections.

Mathematical connections is one of the standards that must be possessed by students through learning mathematics [2]. Mathematical connection is an essential ability that becomes one of learning mathematics goal [3]. It might help students to connect mathematical ideas whether in understanding mathematics or solving mathematics problems. Without a mathematical connection, students should learn and remember too many separate concepts and mathematical procedures. That's why, mathematical connection ability is an important skill for students that need to be developed. By developing mathematical connections, it is possible for students' to change their perception about mathematics. They will see mathematics as an "integrated whole" and not an isolated knowledge where the concepts are partitioned. As an ability, mathematical connections can be measured by some indicators. According to NCTM, there are three indicators of mathematical connections, they are: 1) recognize and use connections among mathematical ideas; 2) understand how mathematical ideas interconnect and build one another to product a coherent whole; 3) recognize and apply mathematics in context outside of mathematics [2]. Garcia-Garcia simplified the indicators into two categories, namely: 1) intra-mathematical connections; and 2) extra-mathematical connections [4]. Sumarmo had mentioned some activities that can be categorized as a mathematical connections, namely: 1) finding connections of some representations and procedures; 2) understanding connections among mathematical concept; 3) applying mathematics in other discipline and daily life; 4) understanding equivalence representation of a concept; 5) finding connections between some procedures in an equivalence representations; 6) applying connections of mathematical concept inside or outside of mathematics [5]. So, based on those explanation, there are three indicators of mathematical connections that will be used in this study, they are: 1) recognize and apply connections among mathematical topic; 2) recognize and apply connections in other discipline; 3) apply mathematics in daily life, and 4) understand how mathematical ideas interconnect and build one another to product a coherent whole.

One of the topic discussed in school mathematics is function. For some students', this topic is very challenging to be understood. So far, the idea of mathematical connections has been examined by Brownell [6], but at that time the idea of mathematical connections was limited to arithmetic [7]. That's why choosing this topic as the main part of the study is considered as the novelty of this research where the aims of this study was to describe the ability of mathematical connections in topic of function.

2. RESEARCH METHOD

This study was a qualitative descriptive. The data were collected by giving a mathematical connection test as an instrument that had been developed by researcher according to indicators of mathematical connections. The subject of this study was 25 grade ten students from one of favorite school in Sukabumi, West Java. The data were analyzed by reducing data, displaying data, and concluding data which is done by the researcher as the main instrument [8]. Data were collected by giving mathematical connection test and having short interview to some representation of the students. The test was contained four questions and it was developed based on mathematical connection indicators. In detail, the following table shows the indicator and its correspondence to the question. To make description clearer, researcher tried to organize the data based on the score obtained by students. The score guideline was referring to [9]. After that, score will be converted and then categorized it by adapting [10]. The following tables show the scoring guideline and the categorization.

3. RESULTS AND DISCUSSION

Based on the result of students' answer from mathematical connection test, it was obtained that mostly students still have problems in answering the questions correctly. The average point was 6.68 of 16 or 43% after conversion. The following table shows a distribution of students' score of mathematical connections:

Table 1: Distribution of students' result.

Range Score	Category	Percentage
$85 \leq X \leq 100$	Very High	0%
$70 \leq X \leq 84.99$	High	4%
$55 \leq X \leq 69.99$	Moderate	20%
$40 \leq X \leq 54.99$	Low	56%
$0 \leq X \leq 39.99$	Very Low	40%

According to Table 1, students' result were dominated with score less than 55 where the most were in low category. In other, majority of students cannot complete their answer and most of them only get score 0, 1, and 2 in each question given. The score distribution of each question is shown in following Table 2.

According to Table 2, the facts were so surprising because only a few of students that were able to answer the question completely. The most scores obtained by students were 2, 1, and 0. Consecutively, 26% students got score 1, 24% students got score 2,

Table 2: Distribution of number of students' score obtained for each question.

Score	Question 1	Question 2	Question 3	Question 4	Total
0	8%	20%	28%	32%	22%
1	28%	8%	28%	40%	26%
2	48%	4%	36%	8%	24%
3	12%	16%	8%	20%	14%
4	4%	52%	0%	0%	14%

and 22% students got score 0 while only 14% students get score 3 and 4 for each. This condition was not good enough since it represents the weakness of students' ability in mathematical connections. For more specific description, the following pictures showed students' response in answering each question that describes their process they performed.

1. Given a function with formula $f(x) = ax^2 - bx + c$ if $f(1) = 3$ and $f(2) = -2$. Find the value of a, b, and c? Show your work.

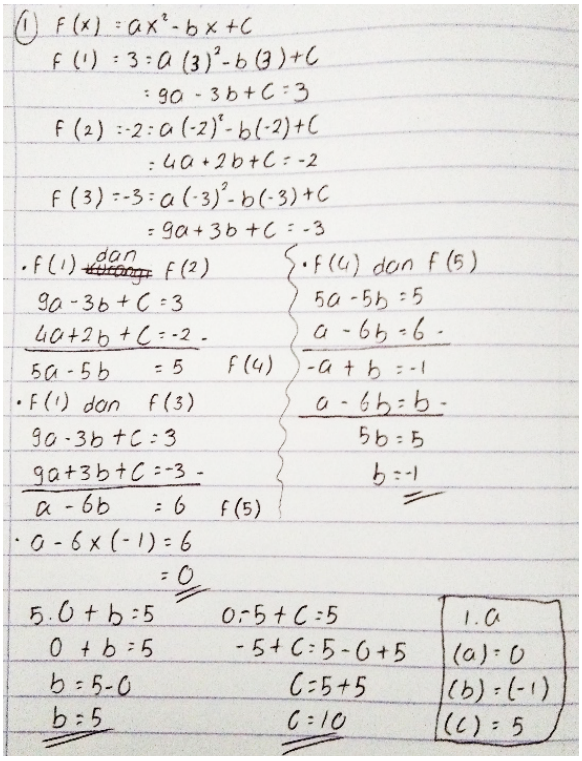

Figure 1: Students' response to question 1.

According to students' response, it can be seen that students had done an appropriate procedure to given information by connecting with formula of function which is $f(x) = ax^2 - bx + c$. Unfortunately, there were some errors that student did, he/she put wrong substitution regarding to domain x and range $f(x)$. After that, student tried to find the variables a, b, and c by using elimination concept which is come from the idea of simultaneous equation. Actually, this showed a systematic process but since there were some errors in early steps, the process was undone. For instance, he/she was able to use mathematical ideas in solving this problem by connecting other concept but the problem was about their understanding towards the concept of function. This condition showed that students' prior knowledge had an important role in solving mathematics problem.

1. In a concept of temperature, there are some scale that have been used to measure it. Among them are Celsius scale (℃) and Fahrenheit scale (℉). If the relationship between these two scale can be expressed with equation $F = (9/5)C + 32$. Determine, (a) equation to convert Fahrenheit scale into Celsius scale. (b) Temperature in Celsius scale when it is 97℉.

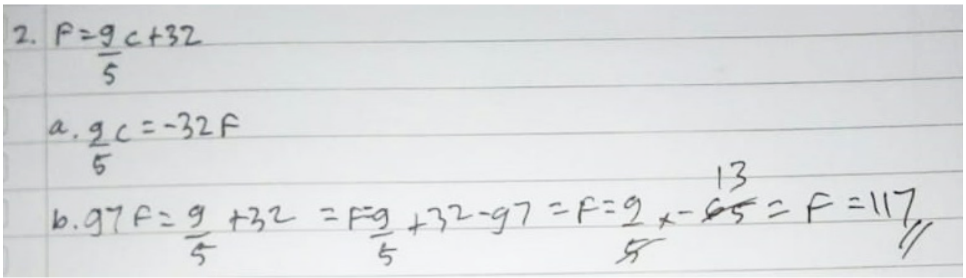

Figure 2: Students' response to question 2.

From Figure 1, the problem should be solved by using algebraic process. In point (a), it seems that students had a problem with mathematical process especially in how to determine the relationship between variable *C* and variable *F*. The answer showed that there were some errors during the process of determining equation of *C*. First error was made when student attempted to put 32 in side of *F*. It was written -32*F*, while the right answer was supposed to be *F* – 32. The second error, he/she did nothing with ratio 9/5 so that the equation was not completely done. In point (b), student failed to find the temperature since he/she used inappropriate equation. This condition due to their lack understanding in concept of inverse function and how to deal with balancing method to solve mathematical equation. To answer this question, most of them still use their memory about the formula that was taught in other lesson and instead of by understanding the mathematical process.

1. A cheese factory needs milk as the main ingredient. To produce cheese, the factory will take two phase using machine I and machine II. Machine I will produce half-done cheese following the formula $f(x) = 0.25x + 1$ while machine II will

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produce well-done cheese following $g(x\ ) = 0.5x\ - - 0.2$ where x represents milk in tons. According to the situation, (a) write down the formula that states the relationship between the amount of cheese produced and the amount of milk (b) find the amount of cheese that will be produced from 100 tons of milk (c) how many tons of milk that will be needed to produce 50 tons of cheese.

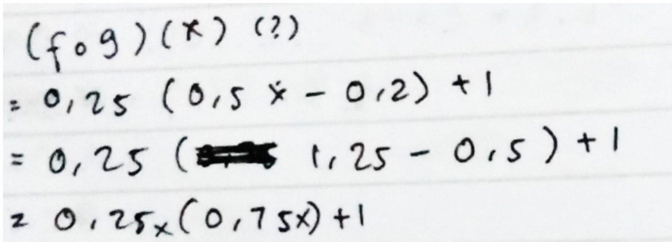

Figure 3: Students' response to question 3a.

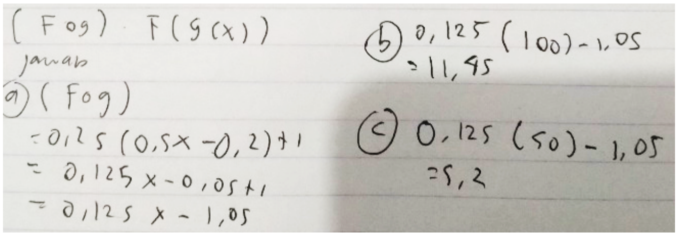

Figure 4: Students' response to question 3b and 3c.

According to students' response of point a, we can see from Figure 2(a) and Figure 2(b) that there were some errors made by students. The first mistake was done when students interpret the context of the question about the relationship between function I ($f(x)$) and function II ($g(x)$). By using concept of composition, most students did inappropriate step where they wrote the relationship between two functions (function I and function II) as a composition of $g(x)$ into $f(x)$ which was written as $f(g(x))$. Since the context said that function I and function II works consecutively, then it was supposed to be a composition of $f(x)$ into $g(x)$ or it can be written $g(f(x))$. This actually was a fundamental error because it will impact to the final result of the answer. Another error which was done by the student related to mathematical process especially when dealing with distributive properties and multiplication of decimal numbers. Meanwhile, in answering question of point b and point c (Figure 2(b)), they failed to find both the value of $g(f(x))$ and the value of x. For point b, they were considered to understand the problem and had used appropriate procedure but there was still some errors which was caused by the previous error that came from the answer of point a. For the last question, they failed to understand the problem and performed inappropriate procedure where they interpreted that they had to find the value of $g(f(x))$ or $f(g(x))$ instead of the value of x.

1. Given a sequence of number as follows: 2, 4, 6, 8,... Can we state it as a function? Explain your answer.

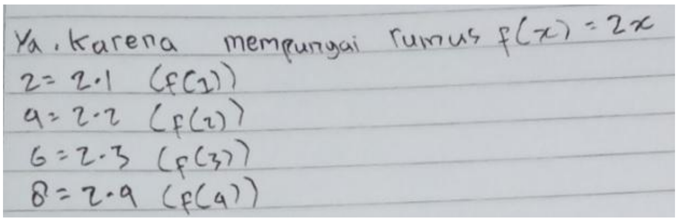

Figure 5: Students' response to question 4.

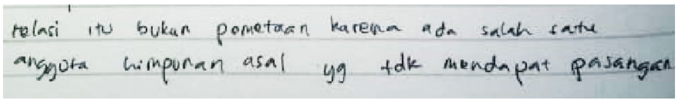

Figure 6: Students' other response to question 4.

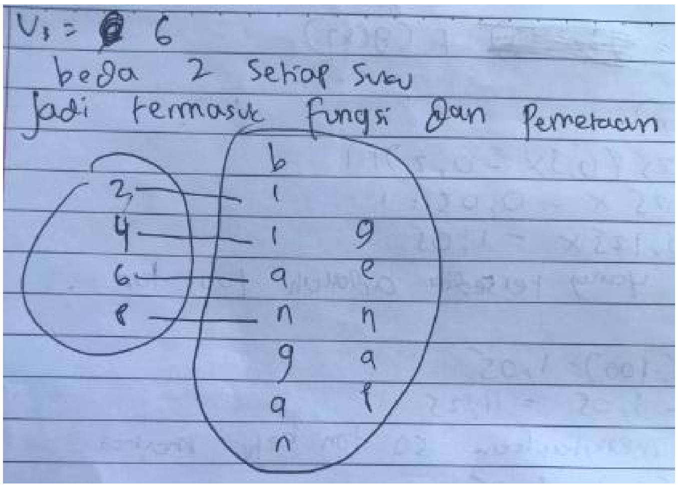

Figure 7: Students' other response to question 4.

From the response, we can see that students still have problem in answering the question. Some students stated that the sequence is not a function since there was only a set of even numbers (Figure 3b). This argumentation show that students still have insufficient understanding about the concept of function. They understand that a function is define by a mapping of domain to exactly one of codomain. In this part, they see the domain as even numbers but they didn't see the codomain (which is the n^{th}-term). For some students (Figure 3a and 4c), they see the sequence as a function, but they don't understand the concept of function. For them, function is a formula that maps an element of a set to element of another set, while the others stated that the sequence was considered to be function because of the pattern that existed. Overall, students still have a problem in connecting the concept of function and sequence. Thus, we can say that they had no appropriate understanding about the concept.

Based on the result, students' mathematical connection ability were in low category. Most students still depend on formula in answering questions instead of understanding mathematical ideas. This condition affects to students' flexibility in thinking process, so that they cannot develop mathematical connection skill properly. This result in line with [11] where in his study only 51.11% students able to apply relationship among mathematical topics in solving problems, and 17.78% able to apply mathematical concept and ideas in other discipline.

Due to students fail in solving daily life problem from this topic, it can refer to [9] who said that students had problem in solving mathematics real life problem because of three factors, namely: 1) interpreting problem; 2) unfamiliar context; and 3) inappropriate strategy. Basically, students were able to understand the problem and the context were familiar to them, but unfortunately they did some mistakes in interpreting the problem. The fact is the lack of understanding of students and their inability to link the problem situation with mathematics made students apply strategies which were inappropriate and causing the wrong results and conclusions. Meanwhile, at level 0, 1, and 2 showed that students could not establish mathematical connections correctly and this caused students inability to understand mathematical concepts in a meaningful way. The results of this study are not much different from the previous researches done before where the ability of students' mathematical connections in solving real-world problems is still limited [12] because students are not careful in reading and understanding sentences about things that are known, asked and how to solve the problem correctly.

Process of connecting mathematical ideas in solving problems require an understanding and knowledge in a mental system. So, internalization of understanding is very important to connect some relating information in building mathematical ideas. This process will involve schema which is owned by students related to their understanding about mathematics [13]. From this phenomena, we can infer that students have lack of prior information and understanding about concept that related to this topic so that they struggled to apply and connect mathematical ideas in solving the problems. For instance, students have low mathematical connection ability and it effected to their mathematics achievement [14].

4. CONCLUSION

The result shows that the percentage of students' mathematical connections in completing task of function was still low. According to the indicators provided, students still could not fulfil in how to connect mathematical ideas to other topic in mathematics, they also mostly use their memory of formula in connecting mathematical ideas to other subject rather than use their understanding. Hence, students could not apply mathematical concept completely in real life because of their restriction in understanding and connecting the topic with the relevant mathematical concepts. Suggestion for future research are: 1) it is necessary for teacher to conduct a deeper teaching concerning on developing mathematical connections in mathematics classroom; 2) to find ways in improving the ability of students' mathematical connections in topic functions.

Acknowledgments

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