Mathematical connection: how is student’s ability to complete a two-variable linear equation system?

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Abstract. The aim of this study is to describe how students make mathematical connections in two-variable linear equation system. This study using three indicators to determine the ability of student’s mathematical connections, there is ability connection between concepts in mathematics, procedures are used by students to solving problems, and ability students to solving contextual problems. Test and interview were used to collect data on ninth-grade students at SMP Negeri 3 Singosari, one of the public junior high schools in Malang, East Java, Indonesia. Based on the test result, the average student’s mathematical connection ability is 76.37 which are in good category. The students' ability to connect between concepts that arise in solving systems of two-variable linear equations uses substitution and elimination using appropriate substitution algorithm or elimination procedures.

1. Introduction

One of the goals in learning mathematics process is the student’s mathematical connections ability. The mathematical connections ability is one of the very useful learning objectives for students since mathematics topic is interrelated to each other as well as to other disciplines [1]. Five main competencies that must be mastered by students in mathematics are mathematical understanding, mathematical problem solving, mathematical communication, mathematical connection, and mathematical reasoning. The ability of mathematical connections is a student's ability to present internal and external relations in mathematics, which includes mathematical connections in several topics, connections with other disciplines, and connections in everyday life [2].

The ability to make mathematical connections at class, the teacher’s role in teaching will make deep mathematical understanding [3]. The mathematical connection becomes more important thing that supports students to comprehend a concept substantially and assists them to improve their understanding on other disciplines through interrelationship between concepts of mathematics and other concepts in other disciplines [4]. Besides that, without mathematical connections, students must learn and remember too many separate mathematical concepts and procedures. From the description above, it can be concluded that mathematical connections are the ability of students to recognize and understand the relationships between mathematical topics; and the ability of students to apply mathematics in other fields or in everyday life [5].

2. Methods

The participants of this study were 32 junior school’s students at SMP Negeri 3 Singosari, Malang, and East Java, Indonesia. The reason for selecting these participants is to promote their mathematical
connection abilities in mathematics learning, and also to give perspective for mathematics teacher about the importance of student’s mathematical connections abilities.

Data of this study were analyzed qualitatively. The instruments of this study were an essay test on mathematical connection, consisting of four questions. The indicators used by researchers to analyze students' mathematical connection abilities include (1) Using relationships between topics in mathematics; (2) Shows a representation of equivalent concepts or procedures; and (3) Applying mathematics in other fields or in daily life. The criteria of student’s mathematical connections abilities based on table 1.

Table 1. Category of Student’s Mathematical Connections Abilities

| No. | Score | Final Score | Category  |
|-----|-------|-------------|-----------|
| 1.  | $X \geq 44$ | 91 – 100   | very good |
| 2.  | $40 \leq X < 44$ | 83 – 90 | good      |
| 3.  | $36 \leq X < 40$ | 75 – 82 | good enough |
| 4.  | $X < 36$ | < 75        | not good  |

3. Result and Discussion

Before collecting data, firstly ensures the validity of the research instrument to be used. Data from instrument validation results of written test questions showed the average of the final score of written test is 32.5. Written test was in a very good category, which means that the research instruments that have been compiled are valid and feasible to use even with slight revisions related to the design question sheet and answer.

Based on the test results on the material of the linear equation system two variables, shows that three students have excellent mathematical connection ability, ten students have good mathematical connection ability and 19 students are in the good enough categories. While the average mathematical connection ability in class VIIIA is 76.37, which means that the connection ability of one class is in category good enough.

Problem number one, students with mathematical connection abilities very good, good, and good enough can use relationships between topics in mathematics, changing the sentence 1/3 dozen to 4, having connections to the addition and subtraction of algebraic material, and connections to the material of Two-Variable Linear Equation System. So, the students are able to perform the process of elimination and substitution in the equation system. This shows that the equivalent representation of the concept or procedure is to substitute the value of the two variables obtained into the equation asked. But at the stage of applying mathematics in other fields or in everyday life, students with mathematical connection abilities are good and good enough. In general, they have not been able to make conclusions with correct and logical sentences[6]. While students with poor mathematical connection ability in the categories are less able to understand the meaning of the question sentence implies they are not able to understand the problem, cannot apply the concepts in everyday life, error in performing operations and cannot create a symbol properly[7]. When the teacher gives a contextual problem, students were still reluctant to seek their own mathematics ideas, but in the next meeting, students will be more familiar[5]. Display of number 1 questions and examples of student answers is shown in figure 1.
In problem number 2, students with mathematical connection abilities very good and good categories will use relationships between topics in mathematics, have connections to flat-build material so as to be able to model two-variable linear equation system problems. Shows the equivalent representation of the concept or procedure, by substituting the value of the two variables obtained into the equation asked[8]. However, some students from the good category were good enough and did not understand the meaning of the sentence and were not even connected with the same tribal addition material which was a mathematical topic that had been studied before. Number 2 and an example of student answers is shown in figure 2

In problem number 3, students with mathematical connection abilities very good, good, and good enough using relationships between topics in mathematics, showing equivalent representations of concepts or procedures and having connections to the addition and subtraction of algebraic material,
connections to material linear equations one variables, and connections to applying mathematics in other fields or in everyday life. Students with poor mathematical connection abilities do not understand the purpose and purpose of the question. In the question, the age of the father and mother will be asked for the next two years, but the students in this category write the age of the father plus the age of the mother then add two[6]. The question number 3 and sample student answers are shown in figure 3.

*Figure 3. Student answers of question no. 3*

In problem number 4, students from four categories of mathematical connection abilities have used relationships between topics in mathematics, but at the stage of showing the equivalent representation of concepts or procedures, students at not good category are not good at applying inter-procedure relationships with less understanding right. Some contexts that we thought would likely lead to meaningful connections because they were at the core of the social and economic life of a specific community did not yield mathematics lessons that deepened students’ mathematical understanding[9]. At the stage of applying mathematics in other fields or in everyday life, almost all students conclude the answer with the right understanding but the sentence they use is only reaching 50% - 75% correct. Question number 4 and student answers are shown in figure 4.
Figure 4. Student answers of question no. 4

Student’s ability to use relationships between topics in mathematics, it already has connections to the addition and subtraction of algebraic material, connections to the material of one-variable linear equations, connections to flat-build material and other mathematical topics will facilitate students in eliminating and substitute in two variable linear equation system. The ability to apply mathematics in other fields or in everyday life also helps students making the right conclusions from the problems. Possible factors that inhibit students’ mathematical connection abilities, two of which are caused by students' understanding of interrelated mathematical topics still applying inter-procedure relationships with limited understanding and students are not accustomed to being faced with mathematical problems related to other material and daily life [10-12].

4. Conclusion
Mathematical connections ability through connecting between topics that have been learned by students. The ability of students' mathematical connections in solving two-variable linear equation system problems by connecting between concepts such as addition and subtraction of algebraic forms, connection to the concept of linear equations of one variable, connection to the concept of elimination and substitution in solving a two-variable linear equation system. In addition, for the problem of linear equation systems related to shape problems, students make a mathematical connection with the concept of shape and how to determine the elements of shape.
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