Analysis of the ability of mathematical connections of middle school students in the field of algebra

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Abstract. The world of education continues to innovate in various fields, including renewal in its implementation strategies. Mathematical connection ability is one of the important abilities possessed by students. Mathematical connections aim to link mathematical problems into mathematical ideas they have. If students can use mathematical connections, learning will be optimal and meaningful. This study aims to describe students' mathematical connection skills in solving the problem of mathematical connections in the algebraic field. This research uses descriptive qualitative research with the subject of the research is class VIII in Surakarta Batik Middle School, amounting to 57 students. Data collection is done by giving a test in the form of a more in-depth essay on mathematical connection skills in the algebraic field. The variables in this study are indicators of mathematical connection ability, namely the connection between mathematical concepts, connections between mathematics and other sciences, and connections between mathematics and everyday life. In this study, students' mathematical connection ability tests were still low. Can be seen from the percentage of each indicator, namely the indicator of the connection between mathematical concepts is 38%, the connection between mathematics and other sciences is 29%, and the connection between mathematics and everyday life is 43%. Students are lowest in connecting mathematics with other sciences.

1. Introduction

Mathematics is one of the subjects taught in every level of school, both elementary school, junior high school, high school to college [1], and mathematics has an important role in everyday life [2]. In various countries not only in Indonesia mathematical connection capabilities are also a concern. In line with this, Nordheimer mentioning education standards throughout the world (for example the NSC in South Africa, NTSM in South America, a diverse curriculum in Germany) recommend that teachers allow students to recognize and make connections between mathematical ideas [3]. Mathematical connection skills students are expected to be able to recognize and use relationships between mathematical ideas, understand how mathematical ideas are interconnected and underlie each other to produce a unified whole, and recognize and apply mathematics outside mathematical context [4].

Students who master mathematical concepts are not themselves smart in connecting mathematics, in a study it was produced that students were able to use mathematical ideas related to real problems, but only a few students were able to explain why the idea was used in that problem [5]. However, if students can connect mathematical ideas the understanding of mathematics will take longer [4]. Through a mathematical connection, students can rebuild their understanding of prior knowledge [6,7], and students are more familiar with new things if they are based on a concept they know [8].
The ability of mathematical connections has two different directions, namely the connection between mathematical ideas and mathematical connections to the real world or other fields of learning mathematics outside [9]. Connections are more important because they support students to increase understanding of the relationship between mathematical concepts and other science concepts [10]. Leonard et al. stated that mathematical connection skills make students and teachers try to find mathematics in real life, especially those related to students' lives and interests, relationships between mathematical concepts and knowing how mathematical concepts relate to other concepts and school lessons [11]. Important for teachers and students in the classroom is making connections because the purpose of teaching is to build a mathematical understanding [7]. Thus mathematical connections can also help and support students in learning mathematics [12].

2. Research methods
This research is a qualitative description with research instruments in the form of essay questions about mathematical connection skills. This study aims to describe the mathematical connection ability of class VIII in Surakarta Batik Middle School students in the field of algebra. In this study analyzed how the mathematical connection capabilities with three indicators are in line with Noto et al., namely the connection between mathematical concepts, connections between mathematics and other sciences, and connections between mathematics and everyday life [13].

The subjects in this study were eighth grade students in Surakarta Batik Middle School who had received straight-line material, time and speed distances and a two-variable linear equation system. The research subjects were selected based on the test of mathematical connection ability that had been given, then carried out analysis and grouping based on high mathematical connection ability scores and low mathematical connection ability scores. The description of the score for the test of the connection ability of the study in this study is shown in table 1.

Table 1. Description of assessment rubrics for tests of mathematical connection skills.

| No | Indicator | Description | Score |
|----|-----------|-------------|-------|
| 1 | connection between mathematical concepts | Students do not work | 0 |
| | | Students can connect between concepts but ways and results are not correct | 1 |
| | | Students can connect between concepts but the way is not correct and the results are correct | 2 |
| | | Students can connect between concepts in the right way but the results are wrong | 3 |
| | | Students can connect between concepts in the right way and the results are correct | 4 |
| 2 | Connection between mathematics and other sciences | Students do not work | 0 |
| | | Students can connect between concepts but ways and results are not correct | 1 |
| | | Students can connect between concepts but the way is not correct and the results are correct | 2 |
| | | Students can connect between concepts in the right way but the results are wrong | 3 |
| | | Students can connect between concepts in the right way and the results are correct | 4 |
| 3 | Connection between mathematics and everyday life | Students do not work | 0 |
| | | Students can connect between concepts but ways and results are not correct | 1 |
| | | Students can connect between concepts but the way is not correct and the results are correct | 2 |
| | | Students can connect between concepts in the right way but the results are wrong | 3 |
| | | Students can connect between concepts in the right way and the results are correct | 4 |
Triangulation is used to confirm data findings. The process of data analysis in this study are: (1) giving a test of mathematical connection ability in the algebraic field and (2) analyzing the test results.

3. Results and discussion
Judging from the results of an average of 57 students in Surakarta Batik Middle School the results of the mathematical connection ability test are still in the low category at 37%. The following are the results of each indicator achieved by students.

Table 2. Percentage of students' mathematical connection abilities.

| Ability Indicator                              | Student Score | Total Score | Percentage Analysis | Category |
|-----------------------------------------------|---------------|-------------|---------------------|----------|
| Connection between mathematical concepts      | 87            | 228         | 38%                 | Low      |
| Connection between mathematics and other sciences | 64            | 228         | 29%                 | Low      |
| Connection between mathematics and everyday life | 94            | 228         | 43%                 | Low      |

It can be seen from table 2 that the average value of the mathematical connection ability of students in Surakarta Batik Middle School is still low, especially in the relation of mathematics to other sciences which only reaches 29%. Based on the percentage of mathematical connection capabilities above, the description of the results of the analysis of mathematical connection skills of students will be divided into students who have high mathematical connection skills and students who have low mathematical connection skills and will be discussed in each indicator in more detail as follows.

3.1. Connection between mathematical concepts
Following are the problems of testing mathematical connection skills with connection indicators between mathematical concepts. In this problem, the connected concept is the system concept of two variable linear equations, gradients, and straight lines.

Problem 1 can be seen in figure 1.

The equation \( g \) and \( h \) are \( 2x-y = -3 \) and \( x + 2y = 2 \), respectively. What is the relationship between line \( g \) and line \( h \)?

Figure 1. Problem 1 on connection indicators between mathematical concepts.

The results of the test answer analysis based on indicators of connection between mathematical concepts are still low at 38%. The following are the test results of students who have high mathematical connection skills and students who have low mathematical connections can be seen in figure 2 and figure 3.
Figure 2. Answers of students capable of high mathematical connections.

Can be seen from figure 2 and figure 3, students with high mathematical connection skills can already know the relationship between the gradient concept and the concept of perpendicular lines in a concise way. But students with low connection skills have not been able to understand the relationship between mathematical concepts from the above problems, as evidenced by low-ability students working on the system concept of linear two-variable equations and stating that the two lines have no relationship.

3.2. Connections between mathematics and other sciences
The following is the problem of testing mathematical connection skills with indicators of connection between mathematics and other sciences. In this problem, the connected concept is the concept of a linear equation system of two variables and the concept of physics.

Problem 2 can be seen in figure 4.

A boat moves along the river water reaches a distance of 52 km in 2 hours. If the ship moves in the opposite direction to the current of the river it reaches a distance of 57 km for 3 hours. What is the difference in boat speed and river speed? Write down the concepts used in the problem!

Figure 4. Problem 2 on indicators of connection between mathematics and other sciences.

The results of the analysis of test answers based on indicators of connection between mathematics and other sciences are still low at 29%. The following are the test results of students who have high mathematical connection skills and students who have low mathematical connections can be seen in figure 5 and figure 6.
Can be seen from figure 5 and figure 6 that students who have high ability can already determine the formula for finding speed while students who have low ability are still wrong in determining the formula so the answer is wrong. Students also have not been able to associate mathematical concepts with physics concepts even though students already know the relationship.

### 3.3. Connection between mathematics and everyday life

The following are the problems of testing mathematical connection skills with indicators of connection between mathematics and everyday life. In this problem, the concept that is connected is the concept of a two-variable linear equation system by looking for wages to be paid.

**Problem 3** can be seen in figure 7.

| Mr. Agus works for 6 days with 4 days including overtime getting IDR 740,000 in salary. Mr. Bobby works for 5 days with 2 days including overtime paying IDR 550,000. Pak Agus, Mr. Bobby, and Pak Cahyo work with the same wage rules. Mr. Cahyo works for 6 days overtime. What is the salary received by Mr. Cahyo? what is the concept used in this problem? |
|---|

The results of the analysis of answers to tests based on indicators of connection between mathematics and daily life are still low at 43%. The following are the test results of students who have high mathematical connection skills and students who have low mathematical connections can be seen in figure 8 and figure 9.
Can be seen from figure 8 that students who have high mathematical connection skills can already connect mathematics with everyday life and have been able to form mathematical models correctly but not concisely in the process. Whereas students who have low connection skills can be seen in figure 9 that students are still wrong in forming mathematical models, because they are fooled by the stimulus given to form the wrong mathematical model.

Based on the results of the test answer analysis, students' low mathematical connection abilities are caused by various influencing factors. One of the factors that influence is that students have not been able to connect mathematics in various aspects, relationships between mathematics, relationships with other fields and the relationship of mathematics in everyday life. This is in line with Hurst which states that in solving mathematical problems, one must be able to connect one concept to another because mathematics has a relationship with one another [14]. In addition, Hotgson states that mathematical connections are problem solving tools [15]. Thus, efforts that can be made to improve mathematical connection skills of students are mathematics teachers must teach mathematics through real concepts in students' personal lives in order to meet all components of the teacher must be able to become student facilitators and mediators related to 21st century competence [16].

4. Conclusion
The results of the analysis description of the mathematical connection ability of students in Surakarta Batik Middle School are still low and not as expected, 37%. Descriptions of students' mathematical connection skills can be seen in each indicator, namely the percentage of connection indicators between mathematical concepts is 38% still in the low category, the percentage of connection indicators between mathematics and other sciences is 29% still in the low category and the lowest indicator in the analysis of connection skills mathematically students, then the percentage indicator of the connection between mathematics and daily life is 43% still in the low category and an indicator that almost half of the students can do well.
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