First-grade junior high school students’ mathematical connection ability

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Abstract. Mathematical connection is an important aspect of learning mathematics. With mathematical connection, learning mathematics will be easier and meaningful because mathematics is structured and interconnected knowledge. This study aimed to describe students’ mathematical connection ability. The subject of this study was 26 first-grade junior high school students. The instruments used in this study were connection ability test and interview guideline. The results of the study showed that only one-third of 26 students fulfilled the mathematical concepts connection indicators. The results also revealed that no student satisfied the indicators of mathematical connection to real life and mathematical connection to other disciplines. These findings provide information that students’ mathematical connection ability is still relatively low. Therefore more attention is needed to increase students’ mathematical connection ability because when the students have good connection ability, they will be able to understand concepts and improve their understanding of other sciences by connecting mathematical concepts with other concepts.

1. Introduction
Mathematics is a subject that helps improve students’ logical, critical, systematic, analytic and creative thinking [1]. Mathematics also plays an important role in science and technology development. Therefore, mathematics has become a very important knowledge in human life.

The aim of learning mathematics, according to National of Council Teachers of Mathematics (NCTM), is developing mathematical ability including problem-solving, reasoning, communication, connection, and representation [2]. Furthermore, the aim of learning mathematics as in 2013 curriculum that guides the student to achieve certain competences. One of the competencies is that student needs to have mathematical connection ability, that is understanding mathematical concepts; explaining the connection between concepts and applying concepts or algorithm fluidly, efficiently, accurately, and correctly in solving a problem.

Mathematics is a structured knowledge and its topics are linked to each other. Mathematics also cannot be separated from other science disciplines and reality in life. Without a mathematical connection, students will have to learn and remember many separated mathematical concepts and mathematical procedures [2,3]. Mathematical connection is very important to be developed in students mind because it will help them understand concepts and connect their understandings about sciences to mathematical concepts and other concepts [4]. Mathematical connection ability is an important competency that a student must reach during the learning process because if the student knows the
connection between concepts, the student will understand mathematics faster and it will create a chance for the student to further develop their mathematical ability [5]. The student can also see that mathematical connection plays an important role in between mathematics topics and non-mathematics topics. By learning the connection between mathematical ideas, the student not only learns mathematics but also learns how to use mathematics. Therefore, mathematical connection ability is important and needs to be understood by the student. If a student can connect mathematical ideas, their mathematical understanding will be deeper and last longer [2].

Bruner and Kenney [6] said there are Theorems on Learning Mathematics as follows: (1) construction theorem that sees the important of the role of related representation to concepts, principles, and mathematics rules, (2) notation theorem that is representation would more simple, if symbols were used, (3) theorem of contrast and variation that sees the need of contrast situations and various situations, and (4) theorem of connectivity. The four theorems work spontaneously in every mathematics learning process. The theorem of connectivity is important to see that mathematics is an interrelated knowledge and is not a partitioned knowledge to its subjects. Mathematics subjects such as algebra, geometry, trigonometry, and statistics are all linked to each other [6].

Mathematics is an integrated knowledge, though in reality mathematics course often partitioned and taught in several separated subjects [2]. To see mathematics as a whole is very important in learning and thinking about connections between mathematics topics. The rule of connectivity by Bruner and Kenney [6] mentioned that every concept, principle, and skill in mathematics is connected to another concept, principle, and skill. Connection structure between mathematics subjects could lead students to do mathematical reasoning analytically and synthetically. Through this, students’ mathematical abilities will develop [6].

Mathematical connection is an ability to connect student mathematics to other mathematics skills and real-life [7]. The mathematical connection ability is a cognitive skill to connect various concepts in mathematics or to connect mathematics concept with non-mathematics concepts [8-10]. Mathematical connection is part of a network structured like a spider's web where determining or changing can be considered a representation of information, and the thread between them as connections or relationships [11]. Mathematical connections can be viewed as a mental process linking mathematical ideas and can be described as a structured network in students’ minds, formed from the link of various mathematical ideas to be used in solving problems, both in mathematics itself, other subjects, as well as problems in everyday life [12]. With mathematical connection ability, a student is expected to identify and use mathematical ideas, understand how mathematical ideas are connected and linked to each other producing one whole unit, then recognize and apply it outside mathematics context [2].

There are two types of mathematical connection: modelling connections and mathematical connections. Modelling connections are a connection between problem situations appeared in real life or other science disciplines with its mathematical representation. Mathematical connections are a connection between two equivalent representations and between processes of solution from each representation [13].

Several mathematical connection indicators are: 1) Connecting conceptual and procedural knowledge, 2) Using mathematics on other topics, 3) Using mathematics on daily activities, 4) Seeing mathematics as one integrated knowledge, 5) Applying mathematical thinking ability and making models to solve problem on other discipline, such as music, art, psychology, science, and business, 6) Knowing connections between topics in mathematics, 7) Identifying various representation to equivalent concept [14].

Based on the explanation above, it could be concluded that mathematical connection is connections between mathematical topics, whether internally that is the connection between mathematics topics connection between mathematics and daily life or other knowledge.

This study aims to describe first-grade junior high school students’ mathematical connection on planes topics. Most studies used indicators between mathematical topics, mathematical connections with daily life and mathematical connections with other disciplines. In this study, we analyzed how students'
mathematical connection abilities with indicators of connections between mathematical concepts, mathematical connections with daily life and mathematical connections with other disciplines.

2. Method
Research type carried out in this study was descriptive research with a qualitative approach. Therefore, this study portrayed and described students’ mathematical connection ability for mathematics problem from test result and interview on planes. This study was carried out on 26-second term first-grade junior high school students. Data were obtained using a validated mathematical connection ability test. The test consisted of three essay questions. Each question represents an indicator, namely connection between mathematics concept, connection with a daily life problem, and connection with other knowledge/discipline and reinforced by interview result.

The students chosen for this study are students who had been learning about planes. First, the students were given the test, and then several students were interviewed to find out their understanding of the test and to find out matters which had not shown by the students on answering the test. Therefore, the researcher understood student mathematical connection ability on planes.

3. Results and discussion
For the first question of the mathematical connection ability test with connection between mathematical concepts as indicator, 3 out of 26 students were able to answer the question correctly, 8 out of 26 students answered the question but the answer is wrong, 9 out of 26 students only wrote known information known from the question without writing the answer, and 6 out of 26 students left the test sheets blank.

For question number 2, with the indicator of connection between mathematics and daily life problem, no one answered correctly. 4 out of 26 students answered the question, but the answer is wrong, 4 out of 26 students only wrote known information from the question without writing the answer, and 18 out of 26 students left the test sheets blank.

For question number 3, with the indicator of connection between mathematics and other knowledge or discipline, no one answered correctly. 9 out of 26 students answer the question but the answer is wrong, 2 out of 26 students only wrote known information from the question without writing the answer, and 15 out of 26 students left the test sheets blank. Details of the answer of the student who answered question number 1 correctly can be seen in Figure 1.

![Figure 1. The answer of the student who answered question number 1 correctly.](image-url)
From the test result, it is found that the student knows how to determine minimum paper sheets needed to create 70 kites by calculating kite area and rectangle paper area first and then connects total kite area with the total paper area. This result is reinforced by the interview result: 
P: how to determine the minimum amount of paper sheets needed to create 70 kites? 
S: first, calculate the kite area and multiply it by 70 because there are 70 kites, then calculate the paper area, after that divide the total kite area with the paper area.

Details of the answer of the students who answered question number 1 wrong with indicator connection between mathematics topics can be seen in Figure 2.

![Figure 2. The answer of the student who answered question number 1 wrong](image)

The scheme expected of the student on solving question number 1 can be seen in Figure 3 and the scheme applied by the student while solving question number 1 can be seen in Figure 4.

![Figure 3. Scheme expected from students](image)  
![Figure 4. Scheme applied by the students.](image)

From the test result as seen in Figure 2, it is known that the student knows how to determine the minimum amount of papers needed to create 70 kites by calculating the kite area and paper area first. However, when the subject tries to calculate the kite area, the subject uses the wrong formula, then the subject cannot connect the total kite area with the paper area. What the subjects should have done is
dividing a total of 70 kite area with the paper area, but instead the subjects multiplied the paper area with 70. The conclusion is students cannot connect one mathematics concept to another yet. The student fails to connect total kite area with the minimum paper area. This result is shown by the following excerpt of the interview which shows that the student is yet able to connect one mathematics concept to another.

P : How did you determine the minimum amount of papers needed to create the kites?
S : There are 70 kites, then 990 (paper area) is multiplied by 70.

In answering question number 2, the scheme expected of a student in solving the question can be seen in Figure 5 and the scheme applied by the student while solving the question can be seen in Figure 6. Based on the test, the students understand about calculating profit from land sales by calculating trapezoid (garden) area first, but the students use the wrong formula for the trapezoid area. Then, the students fail to apply the mathematical concept on solving question number 2 about daily life problem. What the students should have done is converting the trapezoid area into hectare unit first, then multiply the result by the land price per area unit. Next, the total price is subtracted with the price paid to buy the land five years ago. However, what the students had done is multiplying trapezoid area with the price without converting the area unit first. Then, the students multiply the trapezoid (garden) area with the price from five years ago and subtract both results. This shows that the students are yet able to connect mathematics with a daily life problem. This result is reinforced by the interview:

P : How to determine the profit from the land sales?
S : Selling price 5 years ago is subtracted with current sell price. Purchase price multiplied with trapezoid are subtracted with current sell price multiplied with the trapezoid area, without converting the area unit.

From test result of question number 3, it is known that the students fail to use mathematics concept to solve the question. The students also do not know how to connect the mathematics concept to other discipline. What the students should have done is calculating the circumference of the football field and connect it to velocity formula in physics. However, what the students did was multiplying the field area with the running velocity and multiplying it again by 2 because the player runs around twice. This result is reinforced by the interview:

P : How to determine the time needed by the player to run around the field twice?
S : First, calculate field area, then multiply it by 2 and multiply it again with the running velocity.

The scheme that was expected of a student in solving question number 3 can be seen in Figure 7 and the scheme applied by the students while solving question number 3 can be seen in Figure 8. This shows that the students are yet able to connect mathematics with other disciplines. This finding is consistent with what has been discovered by Sugiman [6] that students’ mathematical connection ability reached
an average of 53.8%. This achievement is relatively low. With an average percentage of mastery for each aspect of connections is aspects of connections between mathematical topics 63%, between mathematical topics 41%, mathematics with other subjects 56%, and mathematics with life 55%.

**Figure 7.** Expected scheme.  
**Figure 8.** Scheme applied by students.

A research conducted by Ni'mah, Setiawani and Oktavianingtyas [15] in class IX A of MTs Negeri 1 Jember showed that the level of mathematical connection ability of 26 students are as follow: 7 students have high connection ability, 18 students have moderate mathematical connection ability, and 1 student has a low connection ability. Most of the mathematical connection abilities of students are classified as moderate. The result of a research conducted by Samianto and Kartono [9] states that the average score of mathematical connection abilities between concepts is 94% which is classified as high category, connections between topics are 55% which is medium category, the ability to connect mathematics with other subjects is 40% which is low category and the ability to connect mathematics with everyday life is only 2% which is the lowest ability. Numerous other studies show that students’ mathematical connection is relatively low [16,17]. From this result, it is suggested that math teachers create a learning process that enables students to practice and improve their mathematical connection ability so they are able to succeed in solving mathematical problems.

4. Conclusion
The result of the study shows that only a few students (3 out of 26) were able to connect between mathematical concepts, none of the students was able to connect mathematics with daily life problem and to connect mathematics with other disciplines. It could be concluded that the students’ mathematical connection ability is still considered low and need further research.

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