Ability of students' mathematical connection based on school level in junior high school

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Abstract. This study aims to determine the ability of mathematical connections (Relationships between concepts in mathematics) based on the school level (high, medium, and low). To achieve the objective, 8th-grade students at high, middle, and low-level in Junior High School at Pamulang. Each school level was selected by one school, with a total sample of 116 people. The results of this study resulted in the ability of students’ mathematical connection (relationships between concepts in mathematics) in high school to be successful.

1. Introduction
Connection ability is very important for learning math. Because of mathematical knowledge that contains various interrelationships. Basic mathematical skills consisting of ability: 1. Representation, 2. Problem Solving, 3. Reasoning, 4. Connection, and 5. Communication [1]. The ability of mathematical connections is a person's ability to present internal and external relationships in mathematics that include connections between mathematical topics, connections with other disciplines, and connections with everyday life [2].

Mathematics is the branch of human inquiry involving the study of numbers, the quantities, data, shape, and space of their relationships [3]. Mathematics is the science of organized structure [4]. There is no concept or operation in mathematics that is not connected with other concepts or operations in a system. So the ability of mathematical connections is very important, in order to understand the concept of mathematics well [5].

The current reality, students' mathematical connection ability is very low. Students are not able to relate to concepts in mathematics. Students' mathematical connection ability is still low [6]. The importance of mathematical connection ability because it can help the mastery of understanding the meaningful concepts and help solve problem-solving tasks through the interrelationship between mathematical concepts and between mathematical concepts with concepts in other disciplines [7]. Ruspiani argues that making connections is a way of creating understanding [8].

The student's mathematical connection ability, is it influenced by the treatment provided by the school? This research will explain how students' mathematical connection ability is affected by school level. The issue of this study is how the mathematical connection students by school level?
Based on the formulation of the problem to be answered in this research activity, then this research aims to know the ability of connection math students in school level. So it can be clearly known, the ability of students' mathematical connections at each school level.

Mathematical connections are mathematical associations with other lessons and/or other topics [1]. The ability of mathematical connections is the ability to associate concepts/rules of mathematics with one another, with other fields of study, or with applications in the real world [9]. So the ability of mathematical connections is the ability to link between topics (concepts) in mathematics, between topics (concepts) of mathematics with topics (concepts) on other sciences, and the linkage between the mathematical topic (concept) and daily life. Connections with the real world are defined as creating connections between mathematics and the external world [10].

Mathematics or school mathematics is a science (subject) that contains abstract ideas, in the form of facts, concepts, principles, and procedures (algorithms). These abstract ideas are intertwined that form the 'building' of mathematical science (subjects). The interrelationship between mathematical ideas, such as the linkage between the idea (concept) of the original number with the counting number is the original number with the number zero. The link between the concept of a parallelogram with a square that is a parallelogram that all sides are equal in length and large in all angles is 90°.

Mathematics is a basic science that can be used by other sciences, both natural sciences, social, cultural, and language. In the natural sciences, the mathematics used to simplify the problem and a natural phenomenon and is also used for the calculation in the natural sciences. Like the phenomenon of the speed movement of an object formulated mathematically as a comparison between the distance to time, written as. In the social sciences (mathematics), mathematical models are used to explain the relationship between demand and supply of a good, the relationship between community participation and development success, the relationship between wage labor and productivity.

Mathematical ideas (concepts) are widely used in everyday life, both to simplify the problem and to solve problems in everyday life. The problem of the occurrence of crime somewhere is described geometrically and the sequence of events is presented logically and in accordance with the facts. The sale and purchase transactions in the market use quantitative quantities in the form of numbers contained in the currency. The process of proving a case in court, the judge uses the method of mathematical thinking that is logical, systematic, critical, and meticulous.

More detailed description is that the ability of a mathematical connection to include: a) Connect conceptual and procedural content; b) Using mathematics on other topics; c) Using mathematical in life activities; d) See mathematics as an integrated whole; e) Absorb the ability to think mathematically and make models to solve problems in other lessons; f) Knowing the connection between topics in mathematics; g) Identify different representations for the same concept [6]. Similarly, indicators of mathematical connection capabilities are described as follows [11]:

a. Seeking relationships of various representations of concepts and procedures.
b. Understand the relationships among mathematical topics.
c. Applying mathematics in other fields of study or daily life.
d. Understand the equivalent representation of a concept.
e. Seeking the relationship of one procedure to another procedure in equivalent representation.
f. Applying relationships between mathematical topics, and between mathematical topics and topics outside mathematics.

Similarly, describes the indicators of mathematical connections as follows [1]

1. Recognize and use relationships between mathematical ideas.
2. Understanding the interrelationships between mathematical ideas and forming ideas with one another, resulting in a comprehensive relationship.
3. Recognize and apply the mathematics into and the environment outside mathematics.
Mathematical connections can be divided into 3 parts as follows [12]:

1) The connection between topics and mathematical processes.
   The Connection between topics of mathematics, including inter-mathematical concepts that relate various concepts and procedures in mathematics. As the relation between the concept of 'relation' with the concept of 'function'. A Function is a special form of relation, ie each member in the domain area relates to exactly one member in the codomain area.

2) The connection between mathematical concepts and other disciplines.
   This includes the connection between mathematics that connects the concepts in mathematics with the disciplines outside of mathematics. As the relationship between the concept of multiplying 2 real numbers with the concept of the distance of an object (s) associated with the velocity of the object (v) and time (t) required by the object as $s = v \times t$.

3) The connection between a mathematical concept with everyday life.
   It also includes a connection between mathematics and everyday life that is linking concepts in mathematics with everyday life. As is the relationship between the concept of the area of the rectangle used to determine the extent of a rectangular plot of land.

The benefits of knowledge about mathematical connections are described by as follows in order for students to [12]:

1. Recognizes the equivalent representation of the same concept.
2. Recognizes the relationship of a mathematical procedure or process to a representation procedure equivalent to a representation.
3. Use and assess relationships between mathematical topics.
4. Uses and assesses the link between mathematics and other disciplines.
5. Using mathematics in everyday life.

Benefits of mathematical connections for students and teachers contained in the purpose of learning mathematics in school, as described as follows [13]:

1. Expand the insights of students' knowledge.
2. Looks at mathematics as a whole and not as an independent material.
3. Recognize the relevance and benefits of mathematics both in school and out of school.

The results of research on mathematical connections are much related to the teaching methods used by teachers. Research that focuses on mathematical connections by taking a certain topic is lacking. The studies of mathematical connections are associated with quantum teaching methods that mention that students' mathematical connections are taught through quantum teaching methods with mind maps better than those taught by conventional methods [14]. This shows that the quantum teaching method with emphasize on the comfort of student learning and assisted with concept maps can facilitate students in relating various concepts in mathematics.

Students with high mathematical ability have excellent mathematical connection capability by fulfilling four indicators of mathematical connection ability. This suggests that students are good at having better connection skills than moderate and low-ability students [15].

The amount of mathematical connection capability quantitatively explained by the results of previous study which reported that the level of mathematical connection ability of students is low at 53.8%. Percentage mastery of connections between math topics by 41%, while the inter topic mathematics by 63%. Mathematical connection with other knowledge of 56%. Mathematical connection with daily life is 55%. This shows that math is beneficial to other sciences and daily life with donations of more than 50% [16].

The results of research focusing on mathematical connections, not related to learning methods are still limited to the topic of Pythagorean theorem, that the results of previous study which reported that the ability of mathematical connections of students of grade VIII MTsN Probolinggo in solving the problem Phytagoras's theorem is still low [17].
2. Method

2.1 Types of Research
This research would like to express (describe) about the ability of mathematical connection of student in class VIII SMPN 1 Pamulang [18]. So this research includes descriptive research. Descriptive research related to data collection to give description or affirmation of a concept or symptom, also answer questions related to a research subject at this time.

2.2 Location and Subject of Research
Research location in Kecamata Pamulang Tangerang Selatan, The subject of this research is 8th-grade students at high, middle, and low junior high school.

Table 1. School Level Criteria Data, Number of Schools for Each Level, and School and Number of Selected Students Being Subjects

| No | School Level | School Accreditation | Amount | Selected Schools          | The number of students |
|----|--------------|----------------------|--------|---------------------------|------------------------|
| 1. | High         | A                    | 18     | SMP Dharma Karya UT       | 36                     |
|    |              |                      |        | SMP Islam Terpadu Tamaddun |                        |
| 2. | Medium       | B                    | 5      |                           | 23                     |
| 3. | Low          | C                    | 1      | SMP Annur                 | 57                     |
| 4. | -            | Not accredited       | 11     |                           |                        |
|    |              | /No data             |        |                           |                        |
|    | Amount       |                      | 35     |                           | 116                    |

2.3 Research Instruments
The main instrument in qualitative research is the researcher himself. With the background of the researcher's expertise in mathematics education and the researcher's experience in conducting research related to mathematics education, as well as the experience of researchers following various scientific meetings and publications in the field of mathematics education, the researcher as the main instrument in this study can be trusted in the aspect of validity as well as its reliability.

In addition to the researchers, the supporting instruments used in this study were a set of tests the ability of connection between mathematical concepts as much as 8 items.

2.4 Method of collecting data
The data were collected directly to the research subjects. Creswell explains that research to obtain pure results from students conducted through direct observation. The data collection method used is the test method. Test time for ± 80 minutes [19].

2.5 Data analysis
Analysis of the data used is a qualitative analysis. Qualitative data analysis is an effort done by working with data, organizing data, sorting it into manageable units, synthesizing it, finding and finding patterns, determining what is important and what is learned, and decide what can be told to others [20].
3. Results and discussions

3.1 Instrument validation and testing

The ability of mathematical connection (AMC) Tests are arranged in the form of a written test or essay describing amounted to 8 (eight) points. Expert validation results state that the eight test is valid with a distinguishing feature rather good, good, and very good, and has a moderate degree of difficulty and difficult. Thus, all AMC questions can be used without revision. Reliability of AMC test of 0.85 are in the high-reliability category. This means that AMC test kits are reliable to serve as instruments in measuring students' mathematical connection ability.

3.2 Connection ability and mathematical concepts

Descriptively the student's AMC data is shown in Table 2.

| School Level | Score | Descriptive statistics |
|--------------|-------|------------------------|
|              |       | The number of students | Max Score | Min Score | Standard Deviation | Average |
| Whole        | K1    | 116                    | 30        | 0         | 6.98               | 11.04   |
|              | Total AMC | 116                  | 98        | 0         | 21.99              | 33.41   |
| High         | K1    | 36                     | 30        | 0         | 6.90               | 14.75   |
|              | Total AMC | 36                  | 98        | 3         | 23.59              | 45.33   |
| Medium       | K1    | 23                     | 15        | 4         | 4.44               | 10.87   |
|              | Total AMC | 23                  | 56        | 15        | 16.98              | 39.48   |
| Low          | K1    | 57                     | 22        | 0         | 6.97               | 8.77    |
|              | Total AMC | 57                  | 75        | 0         | 18.02              | 23.44   |

Note:
Ideal Score K1 = 30
Total Ideal Score = 100
K1 = Ability associated with connection between concepts in mathematics

The descriptive comparison of K1 - AMC ability of students between school level and overall is presented in the following figure.

![Figure 1. The ability of connections between mathematical concepts (K1)](image-url)
According to the diagram looks score students' skills in connecting between concepts in mathematics according to the school level sequence. That is K1 high level of students in the school are better than students in schools and the level was low, as is the ability of the students at the school level K1 was better than students in lower level schools. Based on these criteria, the ability of K1-AMC students for each school level and overall is in the medium category.

Does the difference in the K1 ability of the students between the level schools shown in Figure 1 also show statistically significant differences? To test it, then we do one-track ANAVA test and follow-up test using Tukey HSD test if all three groups of data are normally distributed. There is one group of data is not normally distributed, then testing using the Kruskal-Wallis and a follow-up test using the Mann-Whitney test.

The statistical hypothesis used to examine K1 student AMC differences at three school levels is:

\[ H_0 : \text{There were no significant differences in K1-AMC among students at the school level} \]

\[ H_1 : \text{There are significant differences in K1-AMC among students at the school level} \]

The test criterion is if the \( \text{sig value} \) .(2-way) is greater than \( \alpha = 0.05 \), then \( H_0 \) is received, in other cases \( H_0 \) rejected.

The statistical hypothesis used to test data normality is:

\[ H_0 : \text{Normally distributed data} \]

\[ H_1 : \text{Data is not normally distributed} \]

The result of normality test showed that only the data K1-AMC high school level normally distributed, thus testing the difference between K1-AMC school level using Kruskal-Wallis test. The test results are presented in Table 4, following.

| Normality test | Kolmogorov-Smirnov Statistic | df | Sig. (2-way) |
|----------------|-----------------------------|----|-------------|
| K1-AMC Low-Level School | 0.174 | 57 | 0.000 |
| K1-AMC High School Level | 0.293 | 23 | 0.000 |
| K1-AMC High School Level | 0.123 | 36 | 0.183 |

Data on Table 5 show that value \( \text{sig.} \) (2-way) is smaller than 0.05, then \( H_0 \) is rejected. Therefore, it can be concluded that there are significant differences in K1-AMC students at three different school levels. High school students have a mean The highest K1-AMC and low-level students have a mean K1-AMC is the lowest. To know the mean K1-AMC students between different levels of school are significantly different or not, then the Mann-Whitney test.

| School Level | \( N \) | Mean Rank | \( \text{sig.} \) (2-way) |
|--------------|-------|-----------|----------------|
| Low          | 57    | 47.93     |                |
| Medium       | 23    | 58.26     | 0.0011 |
| High         | 36    | 75.39     |                |
Table 5. Mann-Whitney Test Results Data

| School Level | U Mann Whitney | Z  | sig. (1-way) | Information          |
|--------------|---------------|----|--------------|----------------------|
| Low          | 515.500       | -1.497 | 0.067       | $H_0$ be accepted    |
| Medium       | 563.500       | -3.659 | 0.000       | $H_0$ rejected       |
| High         | 268.500       | -2.283 | 0.011       | $H_0$ rejected       |

Based on the results of statistical calculations, it is concluded that K1-AMC students in high school are better than students in middle and low school level. However, K-1 AMC students at middle-level schools did not differ significantly with low-level school students, although descriptively the average K1 -AMC score for middle-level students was higher than that of low-school students. Differences in mathematical connection ability of students at high school level compared with students in low and middle school are indicated by mathematical connection errors in solving mathematical problems by students from the following middle and lower school levels.

Some student errors in solving mathematical connection problems between mathematical concepts are shown by the work of students in solving the following connection problems.

The ability of connections between mathematical concepts (K1) is shown in questions 1, 3, and 6. Problem number 1 as follows. Simplify $(2a^2 - 3a + 4) + (6a^2 + 4a)$

The mathematical concepts contained in the matter are the concept of:

1. Real numbers are: 2, 3, 4, and 6.
2. The variables are a
3. The square of the real number is $2a^2$ and $6a^2$
4. The sum of real numbers is $6a^2 + 4a$
5. Reduction of real numbers is $2a^2 - 3a$

Type error in solving the problem as follows:

\[
(2a^2 - 3a + 4) + (6a^2 + 4a) = 2a^2 - 6a^2 - 3a + 4a + 4 = -4a^2 - 7a + 4
\]

\[
(2a^2 - 3a + 4) + (6a^2 + 4a) = 2a^2 + 6a^2 - 3a + 4a + 4 = 8a^4 - 1a + 4
\]

\[
(2a^2 - 3a + 4) + (6a^2 + 4a) = (2a^2 - 7a) + (10a^2) = -5a^3 + 10a^2 = -15a^5
\]

The type of error 1 in answering question number 1 is $-3a + 4a = -7a$. The type of error is a mistake in linking between mathematical concepts so that an algorithm error occurs. Error in associate terms ($-3a$) with a term $(4a)$. The student views $4a$ as a negative number, so the result of the number with the $-3a$ tribe produces the $-7a$. This shows that students are not able to link number 4 with variable a. Students do not know the meaning of the variable a. This shows that students are not able to connect between mathematics idea 4 with the mathematical idea as a variable. While the type of error 2 is a mistake in linking between mathematical concepts. Error in linking the concept of term $2a^2$ with $6a^2$. In summing these tribes, the student sums the rank of the number a, so that it becomes
The inability to connect between mathematical concepts is because students do not understand the meaning of the operation of rank numbers.

Problem number 3
Simplify form $4p(3p - 2q + 6) - (4p^2 + 3pq)$

Type error in solving problem number 3 as follows:

| Expression                                      | Solution                                      |
|------------------------------------------------|-----------------------------------------------|
| $4p(3p - 2q + 6) - (4p^2 + 3pq)$               | $(12p^2 - 8pq + 24p) - (4p^2 + 3pq)$          |
|                                                  | $12p^2 - 4p^2 - 8pq + 3pq + 24p$             |
|                                                  | $8p^2 - 5q + 24$                              |
| $4p(3p - 2q + 6) - (4p^2 + 3pq)$               | $(12p^2 - 8pq + 24p) - (4p^2 + 3pq)$          |
|                                                  | $12p^2 - 4p^2 - 8pq + 3pq + 24p$             |
|                                                  | $8p^2 - 5q + 24$                              |
| $4p(3p - 2q + 6) - (4p^2 + 3pq)$               | $(7p^2 - 2q + 6) - (7p^3q)$                   |

The error type in associating the multiplication of number -1 with $3pq$ to $3pq$ should be $-3pq$. This type of error is linking between facts -1 with the concept of 3 pq. This shows that students are not able to relate to fact -1 with the concept of variable pq, so that error occurs.

Other types of errors are:

a. Associate the term $-8pq$ with $3pq$ to become $-5q$. The correct association is $-5pq$. This shows that students are not able to relate to mathematical concepts that contain variables.

b. Linking $24p$ with itself to 24. The correct link is $24p$. This shows that students are not able to relate to fact 24 and the concept of variable $p$.

Other types of errors are:

a. Linking $4p$ with $3p$ by summing coefficient 4 with coefficient 3 and variable $p$ at $4p$ with variable $p$ at $3p$ so as to produce $7p^2$. Students do not understand the concept of addition that contains variables. This is evident from summing the rank of the variables. This means that students are not able to associate variables with sum operations.

b. Associate the $4p^2$ by $3pq$ by a sum operation by summing the coefficients with coefficients and rank by rank to produce $7p^3q$. This shows students do not understand the concept of addition that contains variables. This means the ability of students to connect two large sequences containing weak free variables.

Problem number 6: Simplify
Error student F, G, and H in answer number 6 as follow:

| Expression                                      | Solution                                      |
|------------------------------------------------|-----------------------------------------------|
| $\frac{4x^2 + 12x + 8}{2x + 4}$                | $\frac{4(x^2 + 16x + 4)}{2(x + 4)} = \frac{x^2 + 16x + 4}{x + 4}$ |
|                                                  | $= \frac{2(x + 4)(x - 12)}{x - 12}$           |
|                                                  | $= x - 12$                                    |
| $\frac{4x^2 + 12x + 8}{2x + 4}$                | $\frac{4(x^2 + 3x + 2)}{2(x + 2)} = \frac{2(x + 2)(x + 1)}{x + 2}$ |
|                                                  | $= \frac{2(x + 1)}{x + 2}$                    |
This type of error in answering question number 6 is multiply the second term in the numerator is $12x$ the first term in the denominator of which is $2x$ resulting in $24x^2$. This shows that students' ability does not understand the connection of a quadratic equation with multiple-tribe factoring.

Another type of error is to multiply the third term of the numerator ie $8$ with the second term in the denominator $4$ to produce $32$. Such multiplication is not justified. It also shows that students' ability does not understand the connection of a quadratic equation with multiple tribal factoring.

Other types of errors in answering number 6 are:

In changing the form of algebraic summation tribes into a form of multiplication of numbers (coefficients) with algebraic summation tribes that form $4x^2 + 12x + 8$ to $4(x^2 + 16x + 4)$. The second $16x$ in $4(x^2 + 16x + 4)$ is obtained from $4 + 12x$ and the third term $4$ of $4(x^2 + 16x + 4)$ is obtained from $8 = 4 + 4$. This shows the ability of student connections between a quadratic equation form to be a weak form of factoring. Another type of error in answering number 6 is $2(x + 1) = 2(x + 2)$.

4. Conclusions and recommendations

4.1 Conclusion

Based on the results and to the discussion described in Chapter 4, it can be concluded as follows.

a. Descriptively the ability to connect between the concepts in mathematics (K1) of students in high school is better than the students in middle and low school, as well as the ability of K1 students in the middle school is better than the students in lower level school.

b. Statistically, there are significant differences in students' K1-AMC abilities at three different school levels. The ability of K1-AMC students in high school is significantly better than students in low and middle school.

4.2 Suggestion

Based on the results of discussions and conclusions, then to improve students' mathematical connection ability is suggested as follows.

a. The result of the research shows that the most influential on students' AMC ability is the ability to connect between the concepts in mathematics (K1-AMC).

b. Capacity of AMC students based on the results of this study is still in the moderate category. Because of their ability to be improved again in order to have an effect also on improving ability.

c. The teacher should use effective methods so that students can have the ability of mathematical connections (connection between concepts in mathematics).

d. Further researchers should be able to continue the results of this study by focusing on the causes that make the ability of students' mathematical connection is low.

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