Mathematical connections ability of junior high school students viewed from mathematical resilience

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Abstract: The mathematical connections ability is the ability to link between topics in mathematics, between mathematics with other disciplines and between mathematics and life. This study discusses about designing mathematical connection skills in terms of students' mathematical resilience involving 31 students 8th grade students as research subjects. The method used in this research is descriptive method using qualitative. The research instruments used were mathematical resilience questionnaires and essay tests. The results of this study indicate for students who have high resilience, student success in recognizing and using relationships between mathematical ideas (70.31%), students' success in understanding the relationship of mathematical ideas (80.15%), and student success in recognizing and applying one mathematical content to another mathematical content (83.33%). Students who have moderate resilience, student success in recognizing and using relationships between mathematical ideas (48.04%), students' success in understanding the relevance of mathematical ideas (40.28%), and student success in recognizing and applying one mathematical content to another mathematical content (40.28%). Students who have low resilience, student success in recognizing and using relationships between mathematical ideas (35.94%), student success in understanding the relationship of mathematical ideas (39.71%), and student success in recognizing and applying one mathematical content to another mathematical content (37.5%).

1. Introduction
Mathematics or school mathematics is a science (subject) that contains abstract ideas, in the form of facts, concepts, principles, and procedures (algorithms) that are interrelated and related to each other to form a "building" of mathematics or referred to by the eye math. [1]. Humans can develop logical thinking skills, analytical, systematic, critical, and creative, as well as cooperative abilities that are applied in everyday life that can be obtained through mathematics [2]. Mathematics learning is a prerequisite for every other subject; every concept learned in Mathematics learning is interrelated and can explain other concepts. Every existing mathematical concept can be linked to the mathematical concept itself, and the application of the concept can be connected to other fields of science. Students who can link concepts are expected to to solve problems when learning mathematics easily.
The importance of understanding mathematics for students turns out to be incompatible with students' success in learning mathematics. Based on the results of observations in the class conducted by researchers [3], it was found that students' mathematical abilities are still low. Students experience difficulty in conceptual relationships when solving a mathematical problem. The difficulty experienced by students is that they do not understand the next stage of mathematics because they have not been able to relate basic mathematical relationships or the prerequisite in solving these problems in mathematics. This is in accordance with the opinion [4] that students in Indonesia are not accustomed to solving problems because they do not understand and have not been able to connect the prerequisite material to be able to solve the problem.

Based on the 2013 curriculum, the aim of learning mathematics is "students can understand mathematical concepts, explain the interrelationships between concepts and apply concepts or algorithms flexibly, accurately, efficiently, and precisely in problem-solving." Based on the mathematics learning objectives above, one aspect that is emphasized in the 2013 curriculum and the National Council on Teaching Mathematics is the ability of mathematical connections [5]. The ability of mathematical connections has an important role in mathematics because it is one of the standard processes that exists in mathematical abilities in addition to problem-solving, reasoning and proof, communication, and representation [5]. Students who have the ability to connect mathematics have the ability to understand the relationship between mathematical topics. They are able to understand the relationship between mathematics with other sciences and the ability to understand the relationship between mathematics and real-life [6]. Mathematical connection skills are needed for high school students to understand mathematical concepts [7].

The mathematical connection is an ability that students must build and learn because good mathematical connection skills will help students to be able to build relationships of various concepts that exist in mathematics and have the ability to apply mathematics in everyday life. Students who have mathematical connection skills will also benefit from learning mathematics, and students' understanding of the concepts they learn will last longer. In a mathematical connection, there is a relationship that is, internal and external relations mathematically [8]. In line with the opinion [9] that mathematical connections are related to internal connections and external connections. Internal connections include connections between mathematical topics, while external connections include connections with other subjects and connections with everyday life.

Strong and interconnected mathematical concepts imply that aspects of mathematical connections also contain other aspects of mathematics or vice versa. Seeing mathematics as a whole is very important in learning and how important is the relationship between topics in mathematics. A teacher, when presenting concept B, for example, then the teacher must introduce or pay attention to concept A first [10]. When a student can build, develop, and manage the mathematical connection capabilities that they have, they can make connections between sensory experiences and existing schemes [11]. The connection is one of the most important processes of learning and teaching, which is emphasized in the curriculum in mathematics education when connections occur in the brain, then learning related to relevant concepts also occurs [12].

Students who have mathematical connection skills are expected to be prepared in learning mathematics. They can solve problems by connecting with mathematical concepts that have been learned and can apply mathematics in other fields of science so that what has been learned in school can be useful in everyday life [13]. The National Board of Teaching Mathematics also states that with the ability of mathematical connections, students are encouraged (1) to recognize and use relationships
between mathematical ideas, (2) to understand the interrelationship of mathematical ideas, (3) to comprehend the connections between materials of mathematics and other sciences, (4) to recognize and apply one mathematical content to another mathematical content or in everyday life [5]. Usually prominent and often occurs in many research studies that conduct research, among others, on the connection between mathematics and the real world, connections with various disciplines, and connections with mathematics itself [14]. In studies normally carried out in mathematics education, the relationship between mathematics subjects can be said to be an intra-mathematical connection, and when these relationships are connected with other disciplines or real life, they are called extra-mathematical connections [15].

In order for students to be able to use relationships between mathematical ideas, they must understand the information they receive. Thus they can see, be able to explore the problem, try to find solutions by using mathematical ideas to solve problems, whether the problem to be solved has to do with mathematics itself, other disciplines, or with everyday life. In connecting, students must understand newly acquired information to be directed to information that has been previously received [8]. Students who have not been able to connect mathematics then these students must learn and remember too much mathematics that is separate from each other's concepts and procedures. This opinion shows the importance of connections in mathematics learning [13]. With the association between concepts, students are expected to be able to solve the problems faced in mathematics learning. To be able to relate some concepts in mathematics or with other fields of science, it is also necessary to consider non-intellectual aspects and mathematical connections will also be limited to the dimensions of cognitive behavior [16]. Students must have non-intellectual aspects when students solve their problems [5], namely affective skills such as perseverance, never giving up, being curious and confident, and understanding the role of mathematics in real life.

In the learning process, students must have positive attitudes such as resilience that can reduce or even eliminate the negative effects of some unpleasant experiences and experience difficulties in the learning process [17,18]. Resilience is the ability of individuals to deal with any conditions that cannot be avoided positively and pleasantly and can take advantage of these conditions as opportunities to develop themselves better [19]. Seven factors build resilience, namely (1) Emotional Regulation, (2) Impulse Control, (3) Optimism, (4) Causal Analysis, (5) Empathy, (6) Self-Efficacy, and (7) Reaching out.

Jhonston-Wilder et. al. [20] suggested four factors that correlate building resilience abilities related to mathematics: (1) Value, the perception that mathematics is as difficult as whatever they are learning mathematics, they will be motivated to continue learning it because mathematics is a valuable subject and is worth learning (2) Struggle. A recognition that the struggle in mathematics is universal, even for people who have high-level mathematical skills. (3) Growth, the belief that anyone can develop mathematical skills and do not believe that some born with or without the ability to learn mathematics will be tolerant and durable in the face of obstacles. (4) Endurance is an orientation to generate positive responses when faced with negative situations or difficulties in learning mathematics. Students with good mathematical resilience have growth beliefs related to their abilities; they are confident that they will be able to overcome the difficulties being faced, aware of the resources that can help them and are confident in their existence and benefits, maintain confidence in their ability to overcome mathematical obstacles and develop new skills if needed and work together with others if needed. Mathematical resilience affects students in mathematical connection skills, so it is necessary to analyze the ability of mathematical connections in terms of students' mathematical resilience.
2. Method

The type of research used in this study was qualitative research with descriptive methods. This study aimed to analyze the problem-solving abilities of junior high school students in terms of categorizing students’ mathematical resilience. Determination of the subject in this study uses purposive sampling technique. The subjects of this study consisted of 31 students of 8th grade at SMP 1 Kebakkramat in Karanganyar District, Central Java, Indonesia. In practice, some instruments can facilitate the research, including tests of mathematical connection abilities and questionnaires for categorizing mathematical resilience. The questionnaire used in this study was made in the form of a checklist using a Likert scale based on mathematical resilience indicators. The category of mathematical resilience uses the benchmark norm (PAN) with the average student being 68.18 and the standard deviation is 5.38. the results of the categorization can be seen from Table 1.

| Category of Mathematical Resilience | Score Range |
|------------------------------------|-------------|
| High Resilience Mathematics        | $X > 65.49$ |
| Medium Resilience Mathematics      | $65.49 \leq X \leq 70.87$ |
| Low Resilience Mathematics         | $X < 70.87$ |

The mathematical connection ability test instrument in this study used a description test containing questions related to indicators of students’ mathematical connection abilities, including recognizing and using relationships between mathematical ideas, understanding the relationship of mathematical ideas, and recognizing and applying one mathematical content to the content other mathematics. The aim is that the indicators of students’ mathematical connection ability can be better described. The description of the assessment for the mathematical connection ability test used in this study is shown in Table 2.

| Indicator                                      | Description                                                                 | Score |
|-----------------------------------------------|----------------------------------------------------------------------------|-------|
| Recognize and use relationships between ideas  | Do not recognize the relationship between mathematical ideas and do not use the relationship between mathematical ideas | 0     |
|                                               | Recognize the relationship between mathematical ideas but do not use the relationship between mathematical ideas | 1     |
|                                               | Recognize the relationship between mathematical ideas and use the relationship between mathematical ideas but it is not right | 2     |
|                                               | Recognize the relationship between mathematical ideas and use the relationship between mathematical ideas but is not quite right | 3     |
|                                               | Recognize the relationship between mathematical ideas and use the relationship between mathematical ideas appropriately | 4     |
| Understand the relevance of ideas             | Does not explain the relevance of mathematical ideas                         | 0     |
|                                               | Explain the relationship of mathematical ideas but cannot form new mathematical ideas | 1     |
|                                               | Explain the relevance of mathematical ideas and can form new but incorrect mathematical ideas | 2     |
|                                               | Explain the relationship of mathematical ideas and can form mathematical ideas that are new but not quite right | 3     |
|                                               | Explain the relationship of mathematical ideas and can form new mathematical ideas appropriately | 4     |
Recognize and apply one mathematical content to another mathematical content or in everyday life

| Indicator                                                                 | Description                                                                 | Score |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------|
| Cannot recognize one math content into another math content              |                                                                             | 0     |
| Can recognize one mathematical content into another mathematical content  |                                                                             | 1     |
| but cannot apply one mathematical content to another mathematical content  |                                                                             |       |
| or to everyday life.                                                      |                                                                             |       |
| Recognizing and applying one mathematical content to another mathematical |                                                                             | 2     |
| content or into everyday life is not appropriate.                         |                                                                             |       |
| Recognizing and applying one mathematical content to another mathematical |                                                                             | 3     |
| content or into everyday life is not quite right.                         |                                                                             |       |
| Recognize and apply one mathematical content to another mathematical      |                                                                             | 4     |
| content or to everyday life appropriately.                                |                                                                             |       |

3. Results and Discussion

Results retrieval of data from 31 students in grade 8 junior 1 Kebakkramat, there were eight students with a high level of mathematical resilience category, 17 students with a moderate level of mathematical resilience category, and six students with a low level of mathematical resilience category. To determine the extent of students’ mathematical connection abilities based on the category of students’ mathematical resilience, that can be seen from the results of tests that have been adapted to the indicators of students’ mathematical connection abilities. The results obtained in this study explained in Table 3.

Table 3. Percentage of mathematical connection ability seen from students’ mathematical resilience

| Indicator                                                                 | Mathematical Resilience Category |
|---------------------------------------------------------------------------|----------------------------------|
| Recognize and use relationships between mathematical ideas                 | High 70.31%                      |
|                                                                            | Moderate 42.71%                  |
|                                                                            | Low 35.94%                      |
| Understand the relevance of mathematical ideas                             | High 80.15%                      |
|                                                                            | Moderate 48.04%                  |
|                                                                            | Low 39.71%                      |
| Recognize and apply one mathematical content to another mathematical      | High 83.33%                      |
| content or to everyday life                                               | Moderate 40.28%                  |
|                                                                            | Low 37.50%                      |

Based on the percentage of mathematical connection ability above, the analysis of the results of students’ answers related to the problems of mathematical connection ability on each indicator will be discussed in more detail based on the categorization of mathematical resilience.

3.1 Analysis of Students’ Mathematical Connection Capabilities on High Mathematical Resilience

Students with high mathematical resilience group, they have not been able to relate various concepts to each other by using their ideas clearly and structured by proving known values to obtain the equations needed to solve problems. The nitrogen melting point and the Bromine melting point have not been assumed, the student immediately writes down the answer based on the numbers he obtained from the questions. The answer given is correct, because the students have not been able to identify an existing mathematical concept, but they can solve the problems that exist in the problem by using the procedure with their ideas without making the problem into the mathematical model. They students solve these problems concisely and appropriately using their ideas by writing down what is known
from the problem that is not quite right and can determine what is asked of the problem.

Students with high resilience in understanding how to build relationships between mathematical ideas. The students can understand using the relationship between ideas in Mathematics in story problems. The students can understand how to identify links between mathematical concepts. The students can identify the relationship processes contained in the ideas of a mathematical concept. The students can rebuild their understanding of prior knowledge. The students have understood the problem even though it is in the form of a story problem. The students can translate everyday problems into mathematical sentences. The students can provide different examples to make it easier to solve problems. When there is a sentence that the width of the farmer’s garden is 6 meters shorter than its length, the students have been able to make an analogy that for "x = length", then they continued to make an analogy, if the width is shorter than 6 m in length, then the modeling that must be made is "y = x – 6". Therefore, after the students know everything from the questions, they must determine the length and width in advance from circumference the garden that has been known to determine the area. With the circumference already known, the students who have high resilience can determine the length and width value of the garden. The students can identify a given concept and relate it to the procedures contained. The procedure is correct, but there is still an error in determining the solution. The problem that occurs when students determine the final result of the problem is that they make mistakes in determining the area of the garden. The students enter the width value with "6" so that the area obtained is "108". The students think that the width value that is used to determine the value of the circumference.

Students with high resilience can recognize and apply mathematical ideas in everyday life. The students can write the inequality of problems in the form of story problems; the students can write symbols that are suitable to describe these inequalities so that they can determine the completion stating how many buckets containing fish to be eaten by the whale. Students can write the inequality “150 + 30x ≥ 280”... So they can determine the conclusions of the questions asked.

3.2 Analysis of Students’ Mathematical Connection Capabilities on Moderate Mathematical Resilience

Students with moderate mathematical resilience group have not been able to recognize the relationship between different topics in Mathematics gradually according to what is known to facilitate the work on the problems. Students are quite able to change the problem of the story into a mathematical form but it is still not right, and students make the equation that exists on the problem without first making an example.

| Known: Melting point = −7°C  |
|-----------------------------|
| Melt Bromine = $\frac{1}{30}$ |
| Asked: Write down and solve the equation to determine the melting point of nitrogen! |
| Answer: Melt Nitrogen = $\frac{1}{30}xA$ |
| = $\frac{1}{30}x - 7$ |
| = −210 N |

**Figure 1.** Student answer results for recognize and use relationships between mathematical ideas on moderate mathematical resilience

Students solve this problem by trying to use creative ideas as shown in Figure 1, but they do not find the conclusions for the final result with the final result that is correct but the process is still not quite right. Students still do not understand how the concept of fraction multiplication, should be from
the picture above, the product of \( \frac{1}{30} \times -7 \) is \( -\frac{7}{30} \), not \( -210 \text{ N} \). That is because students have not been able to identify procedures in the mathematical process contained in the information presented.

Students with moderate resilience understand how to build connections between mathematical ideas. The students are quite able to identify the relationship between a mathematical concept. The students first search for the circumference of the plot of land, but there is an error in determining the length and width. They correctly write the circumference formula, but incorrectly enter the known value of the problem into the formula. The students cannot change what is known from the problem into a mathematical sentence. Therefore, the final results obtained are not quite right.

The students with moderate resilience can recognize and apply mathematical ideas in daily life. The students have not been able to identify the relationship between a mathematical concept with daily life, have not been able to change mathematical sentences into an inequality. The students have not been able to write the inequality of the problem in the form of a story problem; the students have not been able to write symbols that are suitable to describe these inequalities so in determining the completion stating the number of buckets containing fish to be eaten by the whale, they use trial and error. The students can answer almost right, but the way the work is done by trying to match the numbers still have not found the right final result.

3.3 Analysis of Students’ Mathematical Connection Capabilities on Low Mathematical Resilience

Students with low resilience group have not been able to identify a concept, procedure, and mathematical process contained in the information presented. The students have not been able to explain the relationship between concepts, procedures, and mathematical processes. The students with low resilience are only able to determine the elements that are known and asked of the questions; the students do not have the supportive knowledge to solve the problems that are seen from the results of their completion in the test.

| Known: Melting point = 7°C |
|---------------------------|
| Melt Bromine = \( \frac{1}{30} \) |
| Asked: Determine and resolve to determine the melting point of nitrogen! |
| Answer: \( 7°C + \frac{1}{30} = 23°C \) |

Figure 2. Student answer results for recognize and use relationships between mathematical ideas on low mathematical resilience

The student only answers the problem based on the numbers he knows in the problem as in Figure 2, and sums it up as \( 7°C + \frac{1}{30} = 23°C \). The students have not been able to connect the elements that are known in the problem with existing concepts in Mathematics that should be used to solve a given problem, so they are not able to get the right solution of the problem.

\[
Area = p \times l \\
= 6 \, m \times 60 \, m \\
= 360 \, m
\]

Figure 3. Student answer results for understand the relevance of mathematical ideas on low mathematical resilience

Students with low resilience group, the students are still not able to understand the relationship between topics as in Figure 3; they tend to do it just by looking at the value in the questions without firstly analyze it. The students do not write down the process contained in finding answers because they cannot identify the relationship procedures/processes concerned. The students with low resilience have not been able to identify concepts contained in everyday problems. The students have not been
able to translate everyday problems into mathematical sentences. The students have not been able to associate mathematical ideas with mathematical concepts contained in everyday problems.

| Note: A killer whale has eaten 150 kg of fish today. Eat at least 280 fish per day. Timba can accommodate 30 kg of fish. Asked: Write down the inequality of the situation. Answered = 150 kg + 280 kg + 30 kg = 430 kg + 30 kg = 460 kg |
|---|

**Figure 4.** Student answer results for recognize and apply one mathematical content to another mathematical content or in everyday life on low mathematical resilience

Students only add up the numbers "150 kg + 280 kg + 30 kg" he has gotten from the problem as in Figure 4, without identifying the right procedure to solve the problem because students have not been able to identify concepts contained in everyday problems. Students have not been able to translate everyday problems into mathematical sentences. Students have not been able to associate mathematical ideas with mathematical concepts contained in everyday problems.

Based on the results of the analysis, it can be obtained that students who have high resilience have better connection skills compared to students who have medium and low resilience. That is because students who have high resilience can face any challenges that exist in the problem and work hard with the confidence they have to solve the problem. This is in accordance with the opinion of Newman [21] stating students with high resilience have confidence in their success through hard work; persevering in the face of difficulties; have a desire to discuss, reflect on, and research so that in problem-solving, students with high mathematical resilience tend to be more successful.

Students who have good mathematical resilience have observable characteristics. [22] states that students with good mathematical resilience have the following characteristics: not only have the skills they need to answer the desired questions but also have the necessary mathematical skills and function for the outside world, have the will to develop mathematical, reflective skills and always try to learn mathematics. Think hard and earnest, be able to socialize with others, can see mathematical ideas, and not despair with the ideas they have to make progress even though it seems complicated. [23] Students with good mathematical resilience have confidence in developments in learning mathematics; They do not consider mathematics as a subject that only certain people can learn; Even when they are in trouble, he remains convinced that he will be able to overcome those difficulties and succeed. Therefore, students with high resilience can recognize and use relationships between mathematical ideas, can understand the relationship of mathematical ideas, and can recognize and apply one mathematical content to other mathematical content or in everyday life compared to students who have the ability moderate and low resilience.

The lack of mathematical connection ability in students categorized in moderate and low mathematical resilience caused by (1) poor understanding of students’ concepts of the questions given (2) the lack of students’ knowledge on the subject matter being tested, (3) students unable to model story problems into mathematical models, and students unable to perform mathematical procedures. Students are still having trouble reading the story; students are not careful enough to read and understand the sentence about what is known, asked, and how to solve the problem. This means students have not recognized ideas in interconnected mathematics that is used to solve a problem based on the information contained in the problem. Students have not been able to utilize the relationship between mathematical ideas appropriately to obtain a solution that has not been right. In understanding a problem, students must first determine the elements that are known and are asked in the problem and then can connect these elements with the knowledge students have previously had to determine what is used to solve a problem.
Students who can find relationships from various mathematical concepts and procedures will tend to build new knowledge from knowledge they already know before more easily. The ability to understand mathematical topics helps students understand that concepts in mathematics are interconnected, so students can solve mathematical problems easily. Students will more easily solve a problem better because they can connect with other mathematical concepts. Students who can solve problems in everyday life make students appreciate and appreciate the role of mathematics in their lives.

One reason for the lack of students in understanding mathematical concepts is that teachers are less precise in planning learning implementation. Learning mathematics in the classroom is still teacher-centered using the lecture method and giving clear, practical practice questions on how to solve it [7]. As a result, in the implementation of learning in the classroom, students tend to be passive, not critical of mathematical concepts and problems. To improve students' mathematical connection skills, appropriate learning tools, and learning methods must be used to meet student needs. Therefore, teachers need to arrange learning tools that can build student knowledge, where students will be trained to find their concepts and knowledge. This is also in line with [6] opinion, to improve students 'mathematical connection abilities, appropriate learning tools and learning methods must be used to meet students' needs. Therefore, teachers need to arrange learning tools that can build student knowledge, where students will be trained to find their concepts and knowledge.

A teacher must be able to be a facilitator and mediator in facilitating students to be able to have mathematical connection skills by giving students challenging problems, which are expected to improve their mathematical connection skills [24]. Therefore, a teacher is very important to know mathematical connections, how the connection abilities possessed by students, and be able to create an environment that can support the development of mathematical connection skills among students.

4. Conclusion
Students who have high resilience, they success in recognizing and using relationships between mathematical ideas (70.31%), students' success in understanding the relationship of mathematical ideas (80.15%), and student success in recognizing and applying one mathematical content to another mathematical content (83.33%). Students who have moderate resilience, student success in recognizing and using relationships between mathematical ideas (48.04%), students' success in understanding the relevance of mathematical ideas (40.28%), and student success in recognizing and applying one mathematical content to another mathematical content (40.28%). Students who have low resilience, student success in recognizing and using relationships between mathematical ideas (35.94%), student success in understanding the relationship of mathematical ideas (39.71%), and student success in recognizing and applying one mathematical content to another mathematical content (37.50%). Students who have high resilience have better connection skills compared to students who have medium and low resilience. That is because students who have high resilience can face any challenges that exist in the problem and work hard with the confidence they have to solve the problem. The lack of mathematical connection ability in students categorized in moderate and low mathematical resilience is caused by (1) poor understanding of students' concepts of the questions given (2) the lack of students' knowledge on the subject matter being tested, (3) students are unable to model story problems into mathematical models and students are unable to perform mathematical procedures. To improve students' mathematical connection skills, appropriate learning tools, and learning methods must be used to meet student needs. A teacher who can know how the student's connection ability, then the teacher can easily help the process in accordance with the abilities of their students, therefore students will easily improve their mathematical abilities. Teachers can also provide motivation, instill confidence in their students and be able to increase the mathematical resilience of students, so students will not be easily discouraged, confident, and keep trying when faced with difficult mathematical problems.
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