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Mathematical Connection Profile of Junior High School Students in Solving Mathematical Problems based on Gender Difference

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Abstract:
This study aimed at describing the mathematical connection profile of Junior High School students in solving mathematical problems based on gender difference. The subjects were two eighth grade students who had the same math ability. They were one male student and one female student. Subjects were selected by giving a math ability test, and based on the same scores at a middle level. The research type was exploration with a qualitative approach. Data were taken by interviewing the subject in depth on the basis of Task problem-solving. The problem-solving task contained narrative matter related to Geometry matter and Social Arithmetic. Data credibility used time triangulation. Data analysis was done by data categorization, data reduction, data display, data interpretation, and conclusion. The research results showed that male student connected and used mathematical ideas in the form of facts, concepts/principles, and mathematical symbols in sufficient quantity, and they were linked appropriately and the mathematical ideas connection were used effectively so that it could solve problems correctly. The female student made a connection with mathematical ideas in excessive quantity and the connection was not appropriate, so the student could not solve the problem correctly. This indicated that mathematical connection profile of male student in solving mathematical problems was an efficient, strong, and effective category. On the other hand, the mathematical connection profile of female student in solving mathematical problems was in the category of inefficient, weak, and ineffective. From this result, it is suggested to the math teachers to create a learning process that is able to facilitate all students to practice improving their mathematical connection ability so they are able to succeed in solving mathematical problems.

Keywords: Mathematical Connection, Solving Mathematical Problems, Gender

Introduction

The term "*mathematical connections"* began to be introduced in mathematical education by Brownell circa 1935 [1], [2], but it was still limited to the connection inter concepts in arithmetic. This term becomes famous after [3] entering mathematical connection component to the fourth point of the five standards of mathematical learning process in USA, namely *problem solving, reasoning and proof, communication, connections,* and *representation.* Making connections between mathematical ideas is important because *mathematics is not a set of isolated topics but rather a web of closely connected ideas* [3]. From this thought, the international world incorporates mathematical connections into the mathematical curriculum in various countries, including Indonesia. The Government of Indonesia, in this case [4], [5] makes mathematical connections and problem-solving as the objective of mathematics learning at school, that is to enable students to understand mathematical concepts, to explain the connection between concepts and to use concepts and algorithms flexibly, accurately, efficiently, and in an appropriate way to solve mathematical problems.

Gender is a factor that can affect students' ability in making mathematical connections to be used in solving mathematical problems. Research to find out how the process and the result of mathematical connections made by male and female students in solving mathematical problems is necessary and interesting to do.

Objectives

The aim of this study was to describe how mathematical connection profiles of two students who are as the subjects of this research, namely how the process of male and female students link and use mathematical ideas in solving mathematical problems, and how the results of the link of mathematical ideas, whether efficient, strong, and effective, or vice versa.

Literature Review

Mathematical Connections

There are several indicators of mathematical connection capabilities that teachers need to teach to students, namely *"mathematics instruction should enable students to recognize and use connections between mathematical ideas, ...and*

recognize and apply mathematics in contexts outside of mathematics" [3]. Then it is added again by [6] that *"Effective teachers support students in creating connections between different ways of solving problems, between mathematical representations and topics, and between mathematics and everyday experiences"*. From these opinions, it is clear that teachers of mathematics at schools need to teach students to have the ability to recognize and use mathematical ideas in mathematics itself, apply the connection of mathematical ideas to solve problems in other subjects as well as problems in everyday life.

The mental process in students' minds to connect mathematical ideas can be described as a network. This is said by [1], and [7] that "*mathematical connection is a part of a network structured like a spider's web; where the junctures, or nodes, can be thought of as pieces of representation information, and threads between them as the connections or relationships"*. Mathematical connections can also be described as components of a schema or connected groups of schemas within a mental network. [8] posits that a defining feature of a schema is the presence of connections. The strength and cohesiveness of a schema are dependent on the connectivity of components within the schema or between groups of schemata. From the opinion, it can be concluded that the term "*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. From here, the mathematical connections made by students in solving mathematical problems can be called efficient if the connection of mathematical ideas made by the students is sufficient, not less and not excessive; it is called strong if the connection of mathematical ideas is logical, and the use of connections made by students is effective when it can solve problems correctly. If mathematical connections made by students do not meet the category, it is called inefficient, not strong (weak), and ineffective.

Solving Mathematical Problems

Talking about mathematical connection, it cannot be separated from the activity of solving mathematical problems. [9] argues that problem-solving is a complex mental process that requires visualization, imagination, manipulation, analysis, abstraction and the unification of mathematical ideas. To train students' ability in solving math problems, then we can provide narrative matters that contain various topics. In this study the problem given to students is a matter of mathematical narrative matters that relate to the context of everyday life, containing the matter of Geometry, and Social Arithmetic. [3] states that "*... mathematical connections are" tools "for problems Solving* ...". This means that mathematical connections have a close relationship with "problem-solving", in which the ability of students to connect mathematical ideas will determine the success of students in solving mathematical problems. [10] adds that in order to solve mathematical problems, students should understand the problem and make mathematical connections between ideas in mathematics. Ideas that need to be linked include facts, concepts/ principles, procedures, representations of verbal, images, numerical, symbols, formulas, and mathematical equations.

Gender

The term gender is often associated also with the process of students in making mathematical connections in solving math problems. [11] defines gender as the difference in roles between men and women influenced by social and cultural concepts. Man is a male gender that has masculine behavior and woman is a female gender that behaves feminine. From various research results, for example [12], [13], [14], it is stated that mathematical achievement including mathematics solving problems achievement of male students is better than that of female students.

Research Methodoly

Subject

Subjects in this case study were two eighth graders of Junior High School who had the same math ability and could communicate well. Subjects were selected by giving a Mathematics Ability Test (TKM) to all eighth grade students at SMPN 1 Jember in 2016/2017. Then one male student (initial AFP) and one female student (initial FZ) with the same score of 71.43 were chosen.

Instrument

The instruments were (a) Mathematics Ability Test (TKM) to select the subject and (b) Problem Solving Task (TPM) for collecting data. TKM contained 10 questions that were drawn from the question of standardized National Examination for sixth and seventh-grade students. TPM contained one narrative matter related to the everyday life context and contained Geometry matter and Social Arithmetic. TPM was made of two sets (TPM 1 and TPM 2) and had the same difficulty level. TKM and TPM were validated by three experts and had been declared valid and fit to be used to retrieve research data.

Examples of descriptions on TKM and TPM are given in Table 1.

Table 1. Example of Mathematical Ability Test, and Problem Solving Task

Example of Mathematical Ability Test	Problem Solving Task
1. Determine the result of $13^2 + 6^2$.	Mr. Amir had a square plot of land with a size of 21 meters x 8 meters. A year later this land was hit by a road widening project, so Mr. Amir sold a part of this land in a corner with a right triangle shape with 6-meter and 8-meter sides with a price of $Rp.100{,}000$ per m^2. The income from the sale of the land was used by Mr. Amir to create a fence around his present land. The cost of making a fence of $Rp.50{,}000$ per meter, while for the iron gate along the 4 meters, the cost was $Rp.1{,}000{,}000$. How much money did Mr. Amir need?
2. Rice traders have supply $\frac{7}{10}$ tons of rice. In 2 successive days sold $\frac{1}{4}$ tons of rice and $\frac{1}{5}$ tons of rice. What is the remaining supply of rice?	
3. The ratio of the length and width of the rectangle 3: 1. If the circumference of the rectangle is 72 cm, then specify the area.	

Procedure

This research was an exploratory research using a qualitative approach. The researcher himself collected and

analyzed data so that it could not be replaced by others. The data collection procedure to explore students' mathematical connection activities in solving mathematical problems, started by giving problem-solving task (TPM) to the subject, subject solved the TPM based on his or her ability and wrote down the answer. Next, the researcher interviewed the subject related to aspects of mathematical connection activities. Time triangulation of data was used to have a credible data. This procedure was applied to the two subjects (a male student and a female student in respectively). Then, the collected data (task analysis, interviews) were analyzed by the following steps: 1) data categorization, 2) data reduction, 3) data display, 4) data interpretation, and 5) conclusion [15][16]. At the stage of data categorization, grouping data of mathematical connection is done according to indicators. In the data reduction stage, data mining is done and removing unnecessary data. Next, in stage of data display is done descriptively, that is in the form of description/text, and chart/scan result of students answers. Next in the data interpretation stage, it is interpreted that the meaning of data in accordance with the mathematical connections indicators. The final stage in data analysis is the conclusion to determine how mathematical connections profiles the subjects in solving mathematical problems.

Results and Discussion

Mathematical Connection Profile of Male Student in Solving Mathematical Problems

Based on the observation of the male student (AFP) solved mathematical problems in TPM, the activities done by the student was as follows.

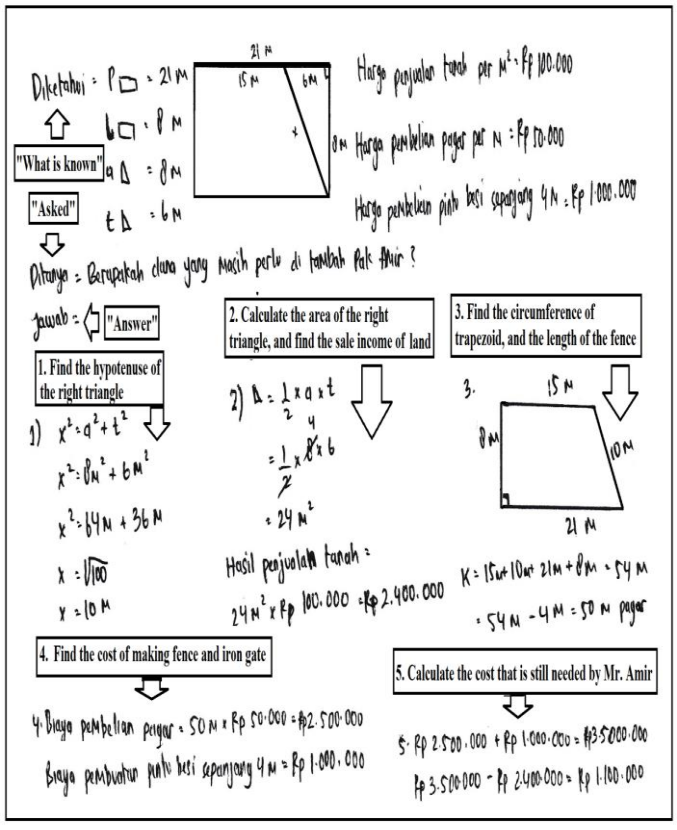

Figure 1. The Answer Sheet of Male Student

First, the student read the problem to understand the meaning of each sentence in the problem. After that, he drew a rectangular image, a right triangle, and wrote the length and width of the rectangle, as well as the base and the height of the right triangle on the image. Next, he wrote "what is known" containing the data or information that he understood from the problem by using verbal sentences and mathematical symbols. The data/information were: rectangle length $(p = 21\ m)$, rectangle width $(l = 8\ m)$, right triangle base $(a = 8\ m)$, and right triangle height $(t = 6\ m)$. He also wrote information about the sale price of land $Rp.100{,}000/m^2$, the cost of making a fence of $Rp.50{,}000/m$, and the cost of making iron gate $Rp.1{,}000{,}000$ for 4 meters. Next, he wrote "Asked", or what the student should count, namely how much money still needed by Mr. Amir to make the fence and the gate?

The next activity the student did was answering the question by writing the word "answer" in the answer sheet, which meant solution. To know the mental activity and understanding of student in making mathematical connections so as to generate answers on the answer sheet, the following presented some interview snippets between the researcher (R) and Subject (AFP).

R	:	Well, when you answer the question, what did you do first?
AFP	:	First, find the hypotenuse of the right triangle
R	:	What formula do you use to find the hypotenuse?
AFP	:	Pythagorean formula
R	:	Then which is the second step?
AFP	:	This (the student points the answer sheet), calculate the area of the right triangle
R	:	What is the formula?
AFP	:	The formula is half-time base time height $(^1/_2 \times a \times t)$
R	:	What do you do next?
AFP	:	Find the sale income of land. Of the land area sold, 24 square meters multiplied by the sale price of land $Rp.100{,}000$ per square meter, the result is $Rp.2{,}400{,}000$
R	:	Please, explain how do you calculate the length of the fence (the researcher points the answer sheet)?
AFP	:	$15m + 10m + 21m + 8m = 54m - 4m = 50m$ $15m + 10m + 21m + 8m = 54m - 4m = 50m$
R	:	Where can you get the number 15 m from?
AFP	:	$21m - 6m = 15m21m - 6m = 15m$
R	:	Then, where can you get the number 10 m from?
AFP	:	The length of the hypotenuse of the right triangle
R	:	Then after this, what will you find?
AFP	:	Finding the cost of making fence and iron gate.
R	:	Then what is next?
AFP	:	Calculate the cost that is still needed by Mr. Amir
R	:	How do you calculate it?
AFP	:	The cost of making a fence is $Rp.2{,}500{,}000$, summed with the cost of making iron gate $Rp.1{,}000{,}000$. the result is $Rp.3{,}500{,}000$. After that reduced with the sale of the land $Rp.2{,}400{,}000$, the result is $Rp.1{,}100{,}000$.

Based on the observation, answer sheet, and also interview, we can see that the male student (AFP) took some steps in answering the problem. The first step was to find the length of the hypotenuse of the right triangle by using the Pythagorean theorem, namely $x^2 = a^2 + t^2$. Here, he used the formula and mathematical symbols, data/facts which were

obtained from the problem, as well as addition arithmetic operation, power, and root squaring. Symbol x for the hypotenuse of the right triangle, a for the base, and t for the height. After being substituted, a = 6, and t = 8, then x = 10. The second step, he calculated the area of the triangle and the income from the land sale. Here, he linked and used the triangle area formula, namely $L = {}^1/_2 \times a \times t$, the concept of social arithmetic (buying and selling), data/facts, symbols, and some counting operations. The mathematical data and symbols used were L for the Area, $a = 6m$ for the base, $t = 8m$ for the height, the sale price of the land = $Rp.100{,}000/m^2$. The counting operations used here were multiplication, and division. After the calculation, the area of the triangle was 24 m^2, and the sale of the land was $Rp.2{,}400{,}000$. In the third step, he created a right trapezoid image to search for trapezoid circumference. Here, he added up all the trapezoid sides, namely $K = 15m + 10m + 21m + 8m$, where $21m - 6m = 15m$. The result was 54 m. To find out the length of the fence built on the land of Mr. Amir, then the trapezoid circumference was subtracted by the length of the gate, so obtained $= 54m - 4m = 50m$. The fourth step, he searched the cost of making a fence: the length of the fence multiplied by the price of making a fence every meter, namely $Rp.50{,}000/m$, so that the cost of making the fence was $Rp.2{,}500{,}000$. The last step, he calculated the cost that was still needed by Mr. Amir. Thus, he calculated the entire cost required to make the fence and gate, namely $Rp.2{,}500{,}000 + Rp.1{,}000{,}000 = Rp.3{,}500{,}000$. After that, it was subtracted from the money from the land sale, which was $Rp.2{,}400{,}000$. So, the cost that was still needed by Mr. Amir to make a fence and gate was $Rp.3{,}500{,}000 - Rp.2{,}400{,}000 = Rp.1{,}100{,}000$. After he finished answering the problem, he checked the correctness of the data, the formula, and the counting operation used. After feeling sure that everything was correct, then he submitted the answer sheet to the researcher.

From the description above, it can be revealed that the mathematical connection profile of male junior high school student (AFP) in solving math problems can be described as follows. The student linked and used connections mathematical ideas to solve problems. The connections of mathematical ideas include the concept of a rectangle linked with the concept of a right triangle and the concept of a trapezoid. Next, he linked these ideas with the concept of triangle area, trapezoidal circumference, and social arithmetic concepts related to the calculation of the cost of fence, gate, and funds still needed by Mr. Amir. He also linked each concept with data/facts, mathematical symbols and counting operations correctly. From the relevance of mathematical ideas that student recognized and used, the connection of mathematical ideas in solving mathematical problems had sufficient numbers and were all required to solve math problems. In addition, the attribution of ideas that were made was correct and logical and used effectively to obtain the correct answer. So, it could be concluded that mathematical connection profile of male junior high school student in solving mathematical problems had included an efficient, strong, and effective category.

Mathematical Connection Profile of Female Student in Solving Mathematical Problems

The activities done by the female student (FZ) in the process of solving mathematical problems based on the observations are as follows.

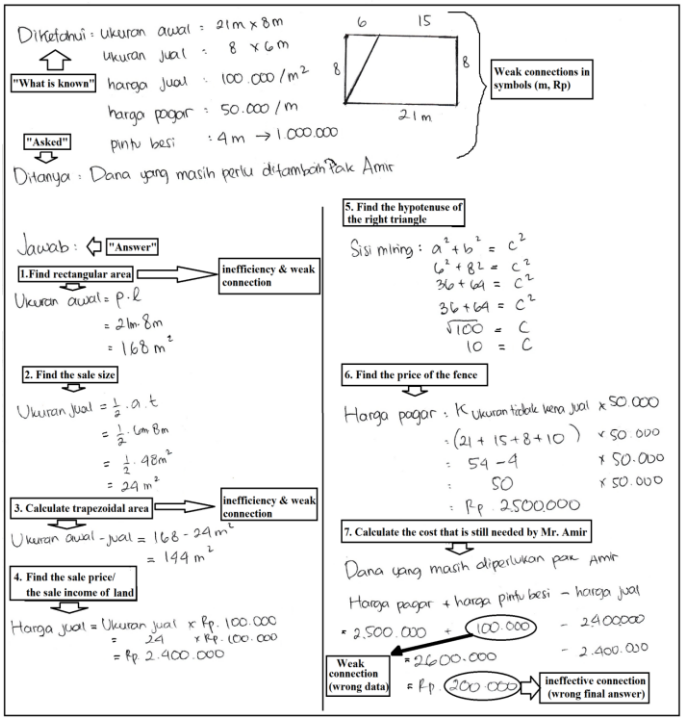

Figure 2. The Answer Sheet of Female Student

First, she read the problem to understand the meaning of every sentence in the matter. After that, she made a rectangular image, a right triangle, along with the measurement of the sides. Next, she wrote "known" which contained the data or information she understood from the problem by using verbal sentences, images, and mathematical symbols. Data/information were: the initial size: $21m \times 8m$, sale size: $8 \times 6m$, the selling price: $100{,}000/m^2$, the price of making fence: $50{,}000/m$, and the iron gate 4 meters $1{,}000{,}000$. Next, she wrote "Asked", or what she should find, namely fund which was still needed by Mr. Amir.

The next activity that the student did was answering the question by writing the word "answer" in the answer sheet, which meant solution. To find out the mental activity and understanding of students in making mathematical connections so as to generate answers on the answer sheet, the following presented some interview snippets between the researcher (R) and Subject (FZ).

R	:	Well, first what did you do?
FZ	:	Searched for initial size
R	:	What did you search for?
FZ	:	Rectangular area
R	:	In the problem/matter, what does this rectangular area mean?
FZ	:	Land of Mr. Amir that has not been sold.
R	:	Then what's next?
FZ	:	Find the sale size
R	:	What does it mean?
FZ	:	Land area sold by Mr. Amir
R	:	Well, in this step, what is the meaning of initial size subtracted from sale size?
FZ	:	Calculating trapezoidal area, namely Mr. Amir's present land area
R	:	Then what's this (pointing at step four)?
FZ	:	Finding the sale price, namely income from the sale of land
R	:	Then, what's next?

FZ	:	Find hypotenuse of the right triangle
R	:	What formula did you use?
FZ	:	Pythagorean formula
R	:	Next, you find the price of the fence. What does it mean?
FZ	:	The point is to find the cost of making a fence
R	:	Please explain how you count it?
FZ	:	$= (21 + 15 + 8 + 10) = (54 - 4) = 50 \times 50{,}000 = Rp.2{,}500{,}000$
R	:	In this last step, what did you do?
FZ	:	Calculated the fund that is still needed by Mr. Amir.
R	:	How?
FZ	:	The price of fence plus the price of the iron gate minus the selling price, the result is $2{,}500{,}000 + 100{,}000 - 2{,}400{,}000 = 2{,}600{,}000 - 2{,}400{,}000 = Rp.200{,}000$.

Based on the observation, the answer sheet, and also interview, we can see that the student took several steps in answering the problem. In the first step, the female student (FZ) searched for "initial size", which meant the land area of Mr. Amir before sale and purchase happened. Here, she used the formula of rectangle area, namely length multiplied by width, so that obtained $L = 21 \times 8 = 168m^2$. In the second step, she searched for "sale size", namely searched for land area sold by Mr. Amir. Here, she used the triangle area formula, namely $^1/_2 \times a \times t$, and the result was $24m^2$. In the third step, she searched for a trapezoidal area, namely the land area which was not sold by Mr. Amir. Here, she used the rectangular area data, and the area of the right triangle already obtained in the first step, and the second step, and used subtraction operation, so as to obtain the trapezoidal area $= 168 - 24 = 144m^2$. In the fourth step, she searched for the income from the sale of Mr. Amir's land by linking and using the data area of a right triangle, and the concept of social arithmetic. The result was $24 \times Rp.100{,}000 = Rp.2{,}400{,}000$. In the fifth step, she searched for the hypotenuse of the right triangle by using the Pythagorean formula, namely, $c^2 = a^2 + b^2$, the data of the right triangle base $a = 6$, and the right triangle height $b = 8$, obtained c $= 10$. In the sixth step, she searched for the cost of making a fence, by linking and using the concept of the trapezoidal circumference, and the concept of social arithmetic. From the calculation result, it was obtained $(21 + 15 + 8 + 10) = (54 - 4) = 50 \times 50{,}000 = Rp.2{,}500{,}000$. In the last step, she searched for the fund that was still needed to be added by Mr. Amir, by summing up the cost of making fence and gate, then subtracting it by the money from the land sale. From the answer sheet, it could be seen that the student was less precise in writing the cost of making the iron gate, which should be Rp.1,000,000, she wrote 100,000, so the final answer was wrong, that was $2{,}500{,}000 + 100{,}000 - 2{,}400{,}000 = Rp.200{,}000$, but it should be $Rp.2{,}500{,}000 + Rp.1{,}000{,}000 - Rp.2{,}400{,}000 = Rp.1{,}100{,}000$. After the student finished answering the problem, the student did not check carefully the correctness of the data, and the counting operation she used so that there were some symbols, such as $meter\ (m)$, and $Rupiah\ (Rp)$. In addition, there was the use of wrong data, namely the cost of the iron gate that should be $Rp.1{,}000{,}000$, she wrote $100{,}000$, so the result of calculation was wrong.

From the description above, it can be revealed that the mathematical connection profile of female junior high school student (FZ) in solving mathematical problems can be described as follows. The student linked and used connections between mathematical ideas to solve problems. The connections of mathematical ideas included the concept of a rectangle linked with the concept of a right triangle and the concept of a trapezoid. Next, she linked the ideas with the concept of rectangular area, triangle area, and trapezoidal area, trapezoidal circumference, as well as social arithmetic concepts related to the calculation of the cost that was still needed by Mr. Amir to make a fence and iron gate. She also linked each concept with data/facts, mathematical symbols and counting operations. Although she had linked and used mathematical ideas to solve problems, it is unfortunate that she linked and used the excessive number of mathematical ideas namely searching for a rectangular area and trapezoidal area, whereas both of these ideas were not needed to solve the problem. The linking of these two mathematical ideas with other mathematical ideas was clearly inappropriate. In addition the student several times did not write the symbols and use the wrong data in the work of counting operations. This error made a wrong final answer. Thus, it could be concluded that the mathematical connection profile of female junior high school student (FZ) in solving mathematical problems included in an inefficient, weak, and ineffective category.

The result was consistent with the result of the study stating that gender-related to mathematical learning outcomes, such as the results of research presented by [12], [13], [14] that mathematical achievement including mathematical problems solving achievement of the male student was better than that of the female student. Based on these results, mathematics teachers need to create a learning process that is able to facilitate all students to practice improving their mathematical connection ability so they are able to succeed in solving mathematical problems.

Conclusion

There were different responses between male and female students in this case study. The research results showed that male student connected and used mathematical ideas in the form of facts, concepts/principles, and mathematical symbols in sufficient quantity, and they were linked appropriately and the mathematical ideas connection were used effectively so that it could solve problems correctly. On the other hand, the female student made a connection with mathematical ideas in excessive quantity and the connection was not appropriate, so the student could not solve the problem correctly. This indicated that mathematical connection profile of male junior high school student (subject AFP in this study) in solving mathematical problems includes an efficient, strong, effective category, while mathematical connection profile of female junior high school student (subject FZ in this study) is inefficient, weak, and ineffective. From this result, it is suggested to the math teachers to create a learning process that is able to facilitate all students to practice improving their mathematical connection ability so they are able to succeed in solving mathematical problems.

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