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The Mathematical Connections Process of Junior High School Students with High and Low Logical Mathematical Intelligence in Solving Geometry Problems

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Abstract**—** *This study aimed to describe the mathematical connections process of students in solving geometry problems. The mathematical connections process was the students' steps in doing mathematical connections. The observed aspects were the internal connections (the interrelationships between mathematical concepts) and external connections (the mathematical interrelationships and outside of mathematics or daily life). The samples of this reasearch were the student with high and low mathematical logical intelligence. The results of the research showed that the students with high logical mathematical intelligence did the internal and external connections in solving geometry problems completely based on polya problem solving steps. Meanwhile, the students with low logical mathematical intelligence did the internal and external connections until the step of understanding the problems.*

Keywords**— External Connection, Internal Connection, Logical Mathematical Intelligence, Problem Solving.***

I. INTRODUCTION

Mathematics is one of the subjects taught in school. The objectives of mathematics learning in the Indonesian curriculum are to improve (1) the problem solving ability, (2) the reasoning ability, (3) the communication ability, (4) the making connections ability, and (5) the ability of representation (Harahap, 2015). Permana & Sumarmo (2007) state that in Indonesian curriculum, mathematical connection is one of the mathematics basic skills which must be mastered by the high school students.

Mathematical connections are relationships between concepts in mathematics; the relationship between mathematical concepts and other disciplines, and the relationships between mathematical concepts and the real world or in daily life. (NCTM, 2000: 274). Mathematical connections are occurred because mathematical science is not partitioned. Mathematical concepts are related between one another. Not only in mathematics itself, they are also related to other disciplines or to real life.

"When student can connect mathematical ideas, their understanding is deeper and more lasting" (NCTM, 2000: 64). If the students can connect mathematical concepts mathematically, so students will have a deeper understanding and can stay longer. The students' understanding of mathematics can be better if students can connect ideas, procedures and concepts from the subjects known to newly lessons received. Students can learn new things easier if it is based on the knowledge known. The importance of mathematical connections for the students is the relationship between mathematical concepts which are related to the mathematics itself (internal connection) and the relationship between mathematics and the outside of mathematics or daily life.

The scientists have done many researches on the importance of mathematical connections. According to Nordheimer (2010) states that the process of mathematical connections is a process of thinking in recognizing and using interrelationships between mathematical ideas. The process of mathematical connections needs to build and improve so that the students can connect mathematics and other sciences or the daily life.

The one of the Mathematical material is geometry. The importance of geometry studied by students is because many geometric concepts are used in real life. According to Soenarjadi (2012), geometry is one of the aspects in Mathematics which can improve logical thinking ability. Improving of logical thinking which is useful in problem solving related to daily life.

The ability of a person in digging information used to solve problems was related to geometry, such as being able to understand the interrelationship of information obtained from the problems so he has the steps in solving the problem appropriately. The ability can be done by

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people who have logical mathematical intelligence. It is with the proposed by Gunawan (2003: 111) that people who have well-developed logical-mathematical intelligence has the characteristic of being able to solve problems, thinking and arranging solutions in a logical sequence. In solving problems related to geometry, the students must be able to understand the problem firstly, then obtain the information from the problem given. The information obtained is translated into mathematical language. After that, the students arrange the plan what have to do to solve the problem. In solving the problem, the students may try to solve minor problems, then draw the generalization. The next step, the students is able to check the solution obtained. It is done in order to obtain a proper and correct solution. The process of solving problems requires the logical-mathematical intelligence. The indicators used in this study is presented in Table 1. below.

Table.1: The Mathematical Connections Indicators of Geometry Problem Solving Tests through Polya Problem Solving Steps

The Steps of Problem Solving	The aspects of mathematics connection	Indicators
Understanding the problem	Internal connection	• knowing the proportion of the lenght of both squares • knowing the average of the lenght of both squares • knowing the relationship of the area of shaded and no shaded region
	External connection	• connecting the problem given with mathematical concept known • being able to determine what known • being able to determine what asked
Drafting the Plan	Internal connection	• determining the lenght of each square side using statistical concept • determining the whole area (the addition of square 1 and 2) • determining whole area (the twice of area of no shaded region) • determining the area of no shaded region (addition of *VPR* and *TSW* right triangle) • detrmining the lenght of *WR* (*SR* side minus *SW* side) • determining the concept of comparison to find the lenght of *UX*
	External connection	• using a definition or symbol in drafting problem solving steps • understanding a definition or symbol in arranging arranging problems solving steps
Executing the plan	Internal connection	Solving the problems based on the problem solving steps made like finding out both of squares' side, finding out all area by adding the area of square 1 and 2, dividing two of all area, the area of triangle to find out the length of *WR*, and using the comparison concept of two triangle to find out the length of *UX*
	External connection	Solving the problems based on the strategy chosen: calculating the area of whole garden, the area of garden with flower planted, the area of garden no flower

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The Steps of Problem Solving	The aspects of mathematics connection	Indicators
		planted. Using the area and the length unit
Rechecking	Internal connection	The students recheck the result obtained. • what was it suitable with the first problem in the question? • what was it suitable with the mathematical procedure?
	External connection	Rechecking the result of calculation using the area and the length unit

In this research, researcher uses the samples of junior high students in knowing the process of mathematical connections. The students at this age have been able to provide arguments or explanations of their ability. Through the preliminary tests and recommendations from mathematics teacher of their communication skills. The research samples were selected one student with high mathematical logical intelligence, and one student with low logical mathematical intelligence. This research entitled "The Mathematical Connections Process of Junior High School Students with High and Low Mathematical Logical Intelligence in Solving Geometry Problems."

II. THE RESEARCH METHOD

This research was descriptive qualitative research which aimed to describe the process of mathematical connections of the students with high logical mathematical intelligence. The role of the researcher was as the main instrument in order to adapt to the class conditions easier so that obtained complete and quite deep data. The research was conducted in IXB class of MTs Fatihul Ulum Tanggul with 30 students in heterogeneous ability level. Researchers took 2 samples with the different categories of logical mathematical intelligence. The research samples were chosen based on logical mathematical intelligence test and consideration of IXB class mathematics teacher of MTs Fatihul Ulum about the fluency of students in communication. The samples chosen were initialized with LM1 for the student with high logical mathematical intelligence, and LM2 for the student with low mathematical logical intelligence.

The research instruments were used in the form of validation sheet. Logical mathematical intelligence tests previously tested were Tes Pemecahan Masalah Geometri/TPMG (Geometry Problem Solving Test) and interview guide. The instrument was validated by the three validators. One validator was a master's lecturer of mathematics education that qualified S3, and two other validators were the lecturers of mathematics education with S3 and S2 qualification. The problem in TPMG about geometry involved the ideas which had been obtained by the students previously, so it could be used to see the process of mathematical connections of the students in solving geometry problems. The aspects of connection included the internal connections (relationships between mathematical concepts) and the external connections (mathematical relationships with out of mathematics or daily life).

In this research, the data were (1) the data of logical mathematical intelligence test result, (2) the data of the connections test result, (3) the data of interview result of research samples. The data obtained were analyzed using flow model data analysis techniques proposed by Miles and Huberman (1992) with the steps (a) reducing, (b) presenting data, and (c) drawing conclusion.

III. THE RESEARCH RESULTS AND DISCUSSION

3.1 The Result of Data Analysis

a. Mathematical Connection Process of the Student with High Logical Mathematical Intelligence (LM1)

The process of mathematical connection of LM1 student in the step of understanding the problem in the answer sheet was by mentioning the information obtained from the problem, among which was known from the problem was the ratio of two sides of the square was 1: 3, the average of the side of both squares was 12 m, the area of shaded and the non-shaded region were same which the lengths of *WR* and *UX* sides asked. It meant that LM1 was able to apply the external connection (able to connect the flower garden problem as a two squares compound and determined what known and asked using his own language). In addition, LM1 was not only able to apply the external connection, he also applied the internal connection in understanding the problem. He knew the area of the shaded area equals to the area of the un-shaded area. The following was LM1 expression during the interview on the step of understanding the problem.

P : *Try to retell the meaning of the question number 1!*

LM1 : *So Mr. Andi had a square-shaped garden combining of two squares, the proportion of squares' sides was 1: 3, the average of two squares' sides was 12 m, the area of unplanted*

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flowers or shaded region was similar with the area of planted flowers regionor un-shaded region. The question was the length of WR and UX side.

The next step, LM1 arranged the plan. He made an internal connection in arranging a plan to find the length of two squares' sides. After knowing the length of squares' sides, then the step taken was to find the whole area of two squares and divided it into two because the shaded area equals the un-shaded area. The un-shaded area was equal to the sum of two right triangles. The following was LM1 expression during the interview.

P : *How were the strategies or steps you used to solve this problem?*
LM1 : *Finding the length of both sides of the squares first.*
P : *After the sides of the two squares found, what was step done?*
LM1 : *Finding the area, mam.*
P : *Which was area?*
LM1 : *Whole area mam, the area of big square plus the area of small square, after that divided by two.*
P : *Why was it divided by two?*
LM1 : *Because the area of garden have been not planted was equal with the area have already planted with flowers.*

LM1 not only did the internal connection, he also applied the external connection when arranging the plan to define a small square area with *Lpk* and the area of big square area with *Lpb*. In addition, he defined that the area of *VPR* triangle with *LΔI* and the area of *TSW* triangle with *LΔII*.

To find the length of *UX* side, LM1 planned to use the concept of proportion of two triangles as expressed by him during the following interview.

LM1 : *Looking for the length of UX*
P : *What did the concept do you use in finding the length of UX?*
LM1 : *The proportion of two triangles*
P : *Which were triangles?*
LM1 : *XQR triangle and VPR triangle*

At the step of doing the completion plan, LM1 worked based on the chosen strategy in solving the problem. First, finding the sides of the two squares. Then, calculating the area of each square and summing it up to obtain the whole area. After that, dividing the whole area into two to find the area of unshaded region. He stated that the area of unshaded region was the sum of the area of triangle I and the area of the triangle II, so that the length of *WR* obtained. The following was LM1's written answer.

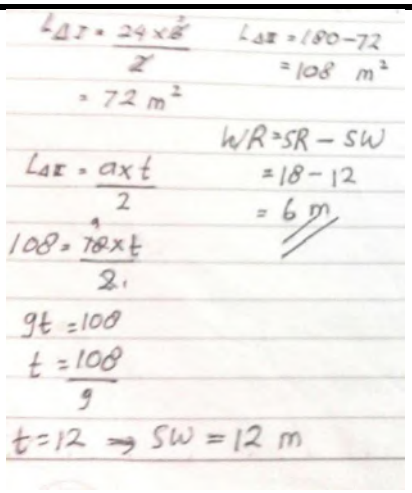

Fig. 1 : The process of mathematical connection in finding the length of WR

It was accordance with what LM1 expressed during the interview.

P : *Try to retell your steps in solving number 1 problem!*
LM1 : *UX Finding the sides of the big and small squares, finding the whole area then summed and divided by two, finding the area of TSW triangle, finding the length of WR, and finding the length of UX.*
P : *Try to explain how you found the length of WR!*
LM1 : *That was the whole area if it is divided by two equals 180 m^2, 180 m^2 for unplanted flowers, 180 m^2 for planted flowers. The garden planted with flowers is a combination of triangle 1 and triangle 2, so 180 equals to the area of triangle 1 plus triangle II, using the right triangle square formula, the area of triangle 1 is obtained 72 m^2. The area of triangle 2 equals to 180 minus 72 equals 108 m^2. Using the area of triangle 2, t found 12, t is the length of SW. To find WR = SR - SW = 18 - 12 = 6 m.*

LM1 kemudian mencari panjang *UX* menggunakan konsep perbandingan yang sudah dipelajari sebelumnya. Berikut adalah ungkapan LM1 pada saat wawancara. Furthermore, LM1 found the length of *UX* using the concept of proportion which was studied previously. The following was LM1's expression during the interview.

P : *Now, Try to retell your way in obtaining the length of UX.*
LM1 : *Finding the length of QX first using the proportion concept of XQR and VPR triangles.* $\frac{18}{QX} = \frac{24}{6}$ *QX equals 4,5 m. So, UX = 6 – 4,5 = 1,5 m*

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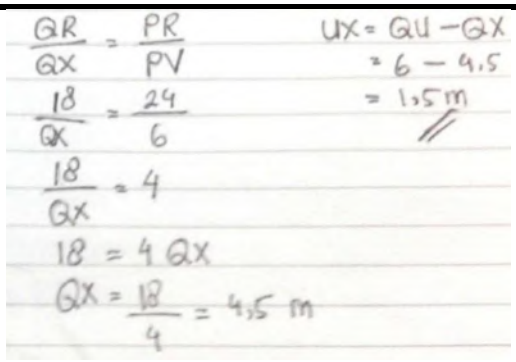

Fig. 2: The process of mathematics connection to find the length of UX

It indicated that during implemented the plan LM1 has done an internal connection by applying the concept of triangle area, square area, and proportion. Moreover, he also used the length unit which meant he able to connect mathematics and beyond mathematics. It meant that LM1 did the external connection.

He also re-checked the result of *WR* length by summing the length of WR and SW so that the length of *SR* obtained. For the length of *SR* and *UQ*, he re-checked using the length of *UQ* plus the length of *SR*. Moreover, he also did the external connection when re-checking using the length unit on both sides.

The following was LM1's expressions in rechecking.

P : *Were you sure of the answers you got? Was it appropriate with the initial problem in the question?*

LM1 : *Yes, I was. Mam.*

P :*How were you sure that your answer appropriate with the initial problem in the question?*

LM1 : *Well mam, the length of WR 6 m, 6 plus 12 equals 18 m, 18 m is the length of the big square's sides. The length of UX is 1.5 m, 1.5 plus 4.5 equals 6 m, 6 m is the length of the small square's sides*

P :*Was your result appropriate with the initial problem in the question?*

LM1 : *It was appropriate mam, so the average of square is 12 m, 12 times 2 equals 24 m. If the big square's sides added a small square side is equal to 24 m.*

The process of mathematical connection of the student with high logical mathematical intelligence (LM1) in completing TPMG was presented in Table 2 below.

Table.2: The Process of Mathematical Connection of LMI

The Steps of Problem Solving	The Aspects of mathematical connection	Students' Activities
Understanding the problem	Internal connection	• Understanding the proportion of both squares 1:3 • Understanding the average of sides of both squares 12 m • understanding the area of the shaded region equals to the area of unshaded region
	External connection	Being able to determine what known and what asked
Drafting the plan	Internal connection	• Being able to determine the lenght of sides of both squares using mean formula • Being able to determine the whole area (the addition of the area of the big square plus the area of the small square • Being able to determine the area of unshaded region (a half of the whole area) • Being able to determine the area of unshaded region (the addition of two right triangles, right triangle I and II) • Being able to determine the length of *WR* side (the length of *SR* side minus the length of *SW* side) • Being able to determine the proportion concept

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The Steps of Problem Solving	The Aspects of mathematical connection	Students' Activities
		of *XQR* and *VPR* triangle to find the length of *UX*
	External connection	• Defining the area of square 1 using *Lpk* and the area of square 2 using *Lpb*. • Defining the area of *VPR* triangle using *LΔI* and *TSW* using *LΔII* • Defining the whole area using *Lsemua*
Executing the plan	Internal connection	Solving using the strategy chosen
	External connection	Using the unit of area and length
Rechecking	Internal connection	Believing the answer obtained and rechecking the result obtained
	External connection	Using the length unit

b. Process of the Mathematical Connection of the Student with Low Logical Mathematical Intelligence (LM2)

In the step of understanding the problem, LM2 firstly got difficulties in understanding the problem. However, after reading several times, he could understand the problem. He mentioned the information from the question of a rectangle-shaped garden. The proportion of the both squares' sides, and the average of the sides of the both squares. Although, it was not written on the answer sheet, He mentioned that the planted flowers garden was the same as the garden unplanted flowers, the unplanted flowers garden was the shaded area in the picture. This indicated that he had the internal connection. He not only mentioned what known, but also mentioned what asked in the question. It meant LM2 also had the external connection. The following was LM2's expression during the interview.

P : *How were your opinion about the question number 1 which you did?*
LM2 : *Difficult*
P : *Did you get the difficulties in doing it?*
LM2 : *Yes*
P : *What were the difficulties?*
LM2 : *I didn't understand what the purpose, mam. I reread mam.*
P : *So, did you understand by doing it in understanding the question?*
LM2 : *Pretty fair*
P : *What the information did you get from the problem?*
LM2 : *The garden shaped of two squares, the proportion of two squares 1:3 and the average of two squares 12*
P : *Any else?*
LM2 : *Iya bu. Eh ada bu, luas taman yang belum ditanami bunga sama dengan luas taman yang sudah ditanami bunga. Luas taman yang belum ditanami bunga itu daerah yang diarsir Yes, mam. The area of unplanted flower garden equals to the planted flower garden. The area of unplanted flower garden was the shaded region.*
P : *What were asked in the question?*
LM2 : *The length of WR and UX sides*

Furthermore, when He was making the plan, finding the lengths of the sides of the both squares by giving *x* for the sides of square 1, and *3x* for the sides of square 2. The following was LM2's written answer.

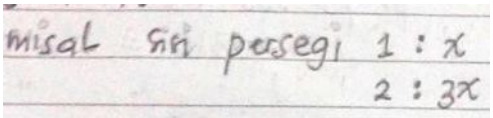

Fig. 3: The Process of the Mathematical Connections Koneksi in Drafting a Plan of Finding the Lenght of the Both Squares' Sides

When LM2 drafting the plan, he planned to find the length of the *WR* using the length of *SR* divided by two. He did not understand that the whole area was 2 times the shaded region. Moreover, he did not understand that the area of unshaded region was a combination of two triangles *VPR* and *TSW*. He also did not understand that through the area of *TSW* triangle the length of *WR* could be found. The following was LM2's expressions during the interview.

LM2 : *Because I want to find the length of WR, the length of WR equals to SW, so divided by 2*
P : *Were you sure that the length of WR equals to SW?*
LM2 : *Emm…actually, I wasn't sure mam, because I didn't know its way.*
P : *Try to find the whole area first, then find the area of the unshaded region. The length of the unshaded region was the combination of two triangles VPR and TSW. The area of TSW triangle used to find the length of SW, after that the length*

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of SW found you could find the length of WR using SR minus SW. Have you understand?

LM2 : *Not yet.*

In drafting the plan, LM2 did not understand in finding the length of *UX* could use the proportion of two triangles. It showed that in drafting a plan, he did not do the internal connection and external connection at once. The following was LM2's expressions during the interview.

P : *Why was the length of UQ divided by 2?*

LM2 : *Because the length of UX equals to QX*

P : *Are you sure UX equals to QX?*

LM2 : *Emmm...*

P : *Try to find the length of QX first using the proportion concept of two triangles VPR and XQR. Then, find the length of UX.*

LM2 : *I didn't understand mam.*

In executing the plan, LM2 used the chosen strategy in finding the length of sides of th both squares. However, he used the wrong step in finding the length of *WR* and *UX*. It indicated that he did not do the internal connection. Moreover, he also did not do the external connection by not using the lenght unit when executing the plan. The following was LM2's written answer.

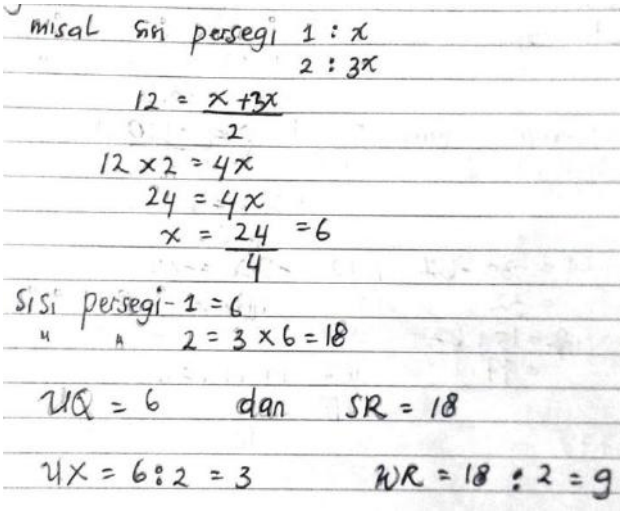

Fig. 4: The process of mathematics connections in executing the plan in finding the length of UX and WR

In solving it, LM2 did not recheck. The mathematical connection process of students with low mathematical logical intelligence (LM2) in completing the geometry problem solving test was presented in the following table.

Table.3: LM2's Process of Mathematical Connections

The steps of problem solving	The Aspects of Mathematical Connection	Students' Activities
Understanding the problem	Internal Connection	• Understanding the proportion of the sides of two squares 1:3 • Understanding the average of the sides of squares 12 • understanding the shaded region equals to the shaded region
	External Connection	Being able to determine what known and asked
Draf-ting the plan	Internal Connection	• Being able to determine the sides of two squares using the average formula • Determining the wrong step in finding the length of *WR* • Determining the wrong step in finding the length of *UX*
	External Connection	• Defining the sides of the fisrt square using *x* and the sides of the second square using *3x* • Not defining the whole area, the area of triangle, the length of unshaded region/ shaded region
Executing the plan	Internal Connection	• Completing the chosen strategy to find the sides of the both squares • Wrong in executing the plan to find the lenght of *WR* • Wrong in executing to find the lenght of *UX*

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The steps of problem solving	The Aspects of Mathematical Connection	Students' Activities
	External Connection	Not using the length unit
Rechecking	Internal Connection	Not rechecking
	External Connection	Not rechecking

3.2 Discussion

Based on the research result data the written answer sheet and the result of interview with research samples showed that the connections process between mathematical concept (internal connection) of the student with high logical mathematical intelligence category (LM1) and the students with low logical mathematical intelligence (LM2) in understanding step could understand the proportion of the sides of two squares, the average of the two square sides, and the area of the shaded region equals to the area of the un-shaded region. Moreover, both LM1 and LM2 also use the external connection in the step of understanding the problem by mentioning what known and asked from the problem given.

Furthermore, LM1 drafted a plan to find the length of *WR* side using the whole area divided by two then using the area of the right triangle, and found the length of the *UX* side using the concept of proportion of two right triangles. In executing the, LM1 planned using his capabilities and skills in applying operations and procedures to find the answers of the problems faced by finding the length of *WR* side and *UX* side. This is in line with the opinion of Hudojo (2003) that in solving problem, the students understand the process of solving the problem and become skilled in choosing and identifying relevant concepts, finding generalization, formulating, planning for completion and organizing the skills had.

The Students with high logical mathematical intelligence category were able to solve the problem of geometry by doing the internal connection, the connections between mathematical topics completely in each step of geometry problems solving. This is in line with the opinion of Bosse (2003) that if the student did the internal connection between mathematical topics then it will make easier for the student to integrate some mathematical concepts into a connected idea and will facilitate students in building knowledge, so that the student with high logical mathematical intelligence was able to solve the problem of the question number 1 correctly because he did the internal connection in the problem solving step.

The Student with high logical mathematical intelligence did the external connection completely in geometry solving problem step. LM1 was able to determine the information obtained from the problem mentioning what known and asked from the problem of number 1. LM1 defined the information obtained using symbols to facilitate the process. This was in line with Orhan's (2008) opinion that students can communicate ideas with symbols, tables, diagrams or other media to explain mathematics and beyond mathematics. In this research, the mathematics and beyond mathematical relationship was intended to the external connection.

LM1 also understood and used the unit for area and length which in Khomariyah's opinion (2014) the student who could use the unit of length and area meant he was able to relate mathematics and beyond mathematics.

The student with low logical mathematical intelligence did not do the internal connection when drafting the plan or executing the plan so that LM2 could not find the lenght of WR and UX sides. This was in line the opinion of Hodgson (1995) that the mathematical connection is problem solving tool. If the student is unable to establish a connection so the connection do not play a role in solving the problem. In line with that opinion Bosse (2003) that the internal connection between mathematical topics can help students to integrate some mathematical concepts into a connected idea. LM2 is unable to work on geometric problems to find the lengths of *WR* and *UX* because LM2 is unable to connect concepts between mathematical topics. Moreover, LM2 did not use the unit of length meter when determining the length of the both square's sides. It showed that LM2 did not do the external connection. Based on the opinion of Khomariyah (2014) student who can use the unit of length and area meant the student has been able to connect mathematics and beyond mathematics.

IV. CONCLUSION

Based on the results of data analysis and discussion of mathematical connection process of the student with high logical mathematical intelligence and the student with low logical mathematical intelligence, it coul be seen that the student with high logical mathematical intelligence able to complete the test of geometry problem solving completely based on the steps of Polya problem solving; understanding the problem , drafting the plan, executing the plan, and rechecking. The Student with high logical mathematical intelligence performed both the internal connection and external connections at each problem solving step. Meanwhile the student with low logical mathematical intelligence did the internal connection and external connections only until the understanding the problem step.

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