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Students' Mathematical Connections in Solving Problems in Terms of Rational Personality Types

Alkans Sofyawati Sutrisno, Toto Nusantara, Susiswo
Mathematic Education-Universitas Negeri Malang
Jl. Semarang 5 Malang, Indonesia 65145. E-mail: alkanssofyawati@gmail.com

Abstract: The purpose of this study is to describe students' mathematical connection of rational type students in solving mathematics problem. The research data was obtained by analyzing the answer sheets and interview of two subjects based on mathematical connection indicators. The results show the process of mathematical connection in everyday life that students do with rational personality type is complete. However, different results are found that in the connection between mathematical concepts and mathematical process connection processes as the equivalent representation of students with rational personality types is not yet complete.

Key Words: mathematical connection, rational personality types

Abstrak: Tujuan penelitian ini untuk mendeskripsikan koneksi matematis siswa bertipe kepribadian rasional dalam memecahkan masalah Matematika. Penelitian ini merupakan penelitian deskriptif-kualitatif. Data diperoleh dari lembar jawaban dan wawancara terhadap dua subjek kemudian dianalisis berdasarkan indikator koneksi matematis. Hasil penelitian menyimpulkan bahwa subjek menunjukkan koneksi Matematika dalam kehidupan sehari-hari secara lengkap. Namun hasil berbeda ditemukan bahwa proses koneksi antar konsep Matematika dan proses koneksi prosedur Matematika sebagai representasi yang ekivalen dari siswa dengan tipe kepribadian rasional adalah belum lengkap.

Kata kunci: koneksi matematis, tipe kepribadian rasional

INTRODUCTION

Mathematical connection is an important element in mathematics learning which is stipulated in the minister of education and culture regulation No. 20 of 2016. The regulation explains that students of primary and secondary education must master factual, conceptual, procedural, and metacognitive knowledge and be able to connect knowledge in the context of real life (Permendikbud, 2016). Mathematical connections relate to students' cognitive abilities such as memorizing, understanding, and applying a concept (Yurlita et al, 2015). When students' mathematical connections go accordingly, student understanding in the brain lasts longer (NCTM, 2000).

Previous research concluded that students' mathematical connections were classified as weak, especially in solving mathematical problems as found by Aini et al (2016), Sugiman (2008), and Nuraini (2014). Nuraini (2014) concluded that it turns out students still encounter problems in connecting mathematical ideas and problems that arise in students largely due to lack of understanding of concepts. Aini et al (2016) and Sugiman (2008) report that the internal connection component in the planning step in problem solving is not mastered by students. In addition, students are not able to connect a mathematical idea with other ideas in problem solving.

Based on the results of preliminary observations, there are many mistakes made by students in identifying mathematical connections. This is also evident from the results of student completion. Strategies and approaches used by students with other students in solving given problems turned out to be different. Some students solve problems by representing problems in the form of drawings, writing a solution plan, followed by solving problems from a given problem. There are also students who immediately write down what is known in verbal form, followed by writing down the knowledge that will be used and solving the given prob-

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lem. In addition there are also students who represent things that are known and asked to use pictures and verbal forms in order to facilitate students in solving problems.

The difference in strategies undertaken by students is influenced by several factors, one of which is the personality of each individual. The personality of each individual can be known by the researchers based on the results of observations by asking the teacher about the characteristics of students. Based on these observations it was found that the character of each student is different. Although there are several students who have the same character, but there are differences in the results of student work. These findings are in accordance with the opinion of Okike and Amoo (2014) which says that differences in personality possessed by each individual, causing them to solve problems with different approaches and decision making. Individuals who have personality will have their own character in expressing mathematical ideas both verbally and in written form (Prasetyo et al, 2017) and also have different processes in solving problems (Dewiyani, 2009).

Numerous research have been done on personality theory, one of which is stated by Keirsey (1998). Keirsey classifies personality types into four namely artisan, guardian, idealist, and rational. The classification is based on three things, namely: (1) the way someone takes information that is based on facts or tends to be based on existing patterns, (2) the way someone determines the plan that is likely not systematic or sequential, and (3) the way someone makes decisions that tend to use logic or use feelings. Personality types in this study follow the classification conducted by Keirsey (1998), namely: artisan, guardian, idealist, and rational.

Many previous studies on personality types such as the research of Hasanah and Sutrima (2016), Hidayatulloh et al. (2013), Kudratullah (2014), and Utami (2015). However, in these studies it, only link the personality types of students with the process of thinking in solving mathematical problems without relating them to students' mathematical connections. Though mathematical connections are also important. This is in accordance with NCTM (2000) which emphasizes the importance of establishing mathematical connections in problem solving. Based on the above data exposure, it is important to research students' mathematical connection processes in solving problems in terms of personality types. The focus of this study is about one of Kersey's personality types, the rational type. Rational type individuals are specifically chosen in this study because they are independent individuals, focus on problem solving, analyze the way they work in the hope of making them work well and believe in the logic of Keirsey (1998).

METHOD

This research was a descriptive-qualitative study to describe the mathematical connection process of high school students with rational personality types in solving the problem of quadratic inequality. The material used in this study was carried out in one of the high school schools in Malang involving 39 students. The subjects of this study were X graders with rational personality types. First, the subjects were given a Keirsey (1998) personality type questionnaire in order to determine their personality types. Three students with rational personality types were taken from the whole. Based on the criteria: (1) affable and (2) capable, the researchers determined two research subjects (SR1 and SR2). Data collection techniques in this study used test and interview instruments. The data obtained in this study were student answer sheets and transcripts of researchers' interviews with students. Furthermore, the data obtained were analyzed based on indicators of mathematical connection processes i.e. (1) daily life mathematical connections, (2) connections between mathematical concepts, and (3) connections of mathematical procedures as equivalent representations (Ramdani, 2012).

RESULTS

The results in this study describe the process of mathematical connection of high school students with rational personality types in solving the problem of quadratic inequality. The elaboration of the results of the study refers to three indicators of the mathematical connection process that have been determined by the researcher. Following are the results of research on the mathematical connection process of students with rational personality types (SR1 and SR2).

The initial step taken by SR1 in solving problems begins with rewriting the information that is known and asked on the answer sheet. Information written includes: the perimeter of a rectangle that is 30 m. then SR1 writes the depth of the pool to be made by Mr. Reza, which is 3.75 m. Furthermore SR1 wrote the height of the water from the surface of the pond is 0.25 m and the volume of water is 175 m^3. Not only that, SR1 also wrote what was asked was the length of the catfish breeding pond. The results of SR1's work in rewriting the information that is known and asked are presented in Figure 1.

Based on this information, SR1 translated written test information related to everyday correctly. However, SR1 made a mistake in representing the least meaning to be the same sign as "=". Thus, the researchers conducted interviews to confirm information that was written by SR1. Here are the reviews:

Researcher: You already did the written test that I gave you. Well, in your opinion, what information is known from this problem?

SR1: "K" around the pond is 30 m, the depth of the pond is 3.75 m, the height of the water from the lip of the pond is 0.25 m, and the "V" is the volume of bu water which is 175 m^3 and continues to be the same Ma'am, which asked "p" ma'am, the length of the pond.

Researcher: Well, what is known from the volume of catfish breeding ponds?

SR1: That's ma'am, the water volume is at least 175 m^3.

Researcher: What does that mean?

SR1: That is to say, the volume in the pool is at least 175 m^3, so the water can be 175 m^3 or more, ma'am.

Researcher: How to write a mathematical model of water volume of at least 175 m^3?

SR1: $V \geq p.l.t$ or $175\ m^3 \geq p.l.t$[1]

Researcher: Why on the answer sheet do you write the sign

SR1: Oh, that was wrong, Ma'am.

Next, SR1 determined the width of the pool using known information, which is the perimeter of a rectangle. Before determining the width of the pond, SR1 must first write the formula for the perimeter of the rectangle, $K = 2p + 2l$. Following is the formula used SR1 (Figure 2).

After writing the perimeter formula, then SR1 applied integer operations to get the width of the pool, which is $l = (15 - p)$. The SR1 step in obtaining $l = (15 - p)$ is presented in Figure 3.

Furthermore, SR1 determined the height of water in a pond by applying a number operation. SR1 obtained a water height of 3.50 m by connecting the depth of the catfish breeding pond to the water level limit from the surface of the pond. Following are the steps taken by SR1 (Figure 4).

The next step taken by SR1 was using the width of the pool $(15 - p)$ and the height of water which is 3.50 m to determine the length interval. SR1 first substituted $l = (15 - p)$ and t water = 3.50 m to the inequality $V \leq plt$, thus the results obtained $p^2 - 15p + 50 \leq 0$. The SR1 steps in substituting $l = (15 - p)$ and t water = 3.50 m to $V \leq plt$ are presented in Figure 5.

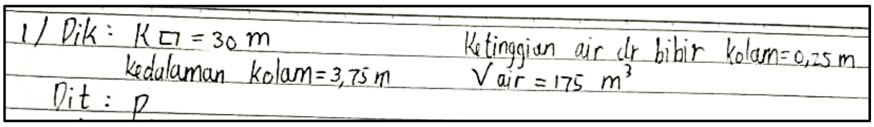

Figure 1. Information Obtained by SR_1

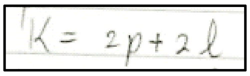

Figure 2. Perimeter Equation Used by SR_1

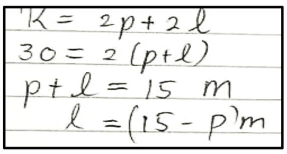

Figure 3. SR_1 Work in Determining Pool Width

[1]According to international system of units, *p* refers to *l*; *l* refers to *w*; *t* refers to *h*; *K* refers to *P*

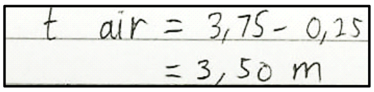

Figure 4. SR_1 Work in Determining Water Height

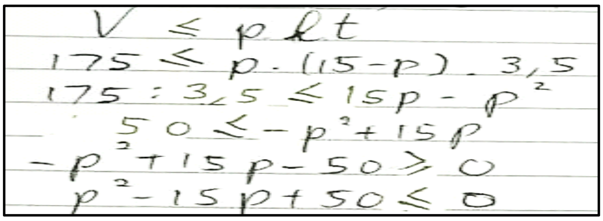

Figure 5. SR_1 Work in Determining Pool Width and Water Height

Furthermore, the results of $p^2 - 15p + 50 \leq 0$ which have been obtained were used to determine the length of the pool by connecting $p^2 - 15p + 50 \leq 0$ with the concept of quadratic equations. Thus, the results obtained as in Figure 6.

After obtaining $(p-5)(p-10) \leq 0$, then SR1 calculated long intervals of catfish breeding ponds using number lines. SR1 obtained $p = 5 \vee p = 10$ from equation $(p-5)(p-10)$. Furthermore, SR1 determined the intervals by drawing and dividing the number line into three regions, namely area $p < 5$, area $5 \leq p \leq 10$, and area $p > 10$. SR1 took any number in the three regions then substituted the inequality of the equation $p^2 - 15p + 50 \leq 0$. Thus, the results obtained are $5 \leq p \leq 10$. In other words, SR1 found that the long interval of catfish breeding ponds was $5 \leq p \leq 10$. The SR1 work when determining the length interval for catfish breeding ponds is presented in Figure 7.

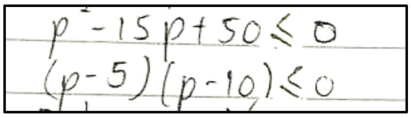

Figure 6. SR_1 Work in Connecting Quadratic Equation

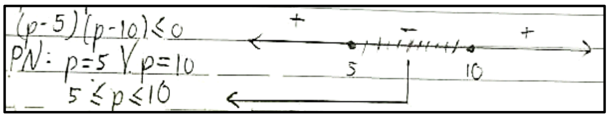

Figure 7. SR_1 Work in Determining Length Interval of Pool

Furthermore, SR1 makes the conclusion that the length interval for catfish breeding ponds is $5 \leq p \leq 10$ with a condition of $p \neq 7{,}5$. That is because if $p = 7{,}5$, then length = width thus the surface of the catfish breeding pond is square. Furthermore, SR1 provided information on how to determine length and width if the length or width is known by using the formula $p + l = 15$. The work of SR1 when making conclusions is presented in Figure 8.

Overall, the following is a description of the SR1 mathematical connection process in solving the written test presented in Figure 9. Further explanation about Figure 9 is presented in Table 1.

SR2 began to solve the problem by drawing a sketch of a catfish breeding pond in the form of blocks based on information known on a written test. Furthermore, SR2 translated the depth of catfish breeding ponds equal to the height of the rectangular prism. Thus, SR2 added information to the sketch that the rectangular prism height is 3.75 m. After that, SR2 also wrote that the height of water is 3.5 m. SR2 ob-

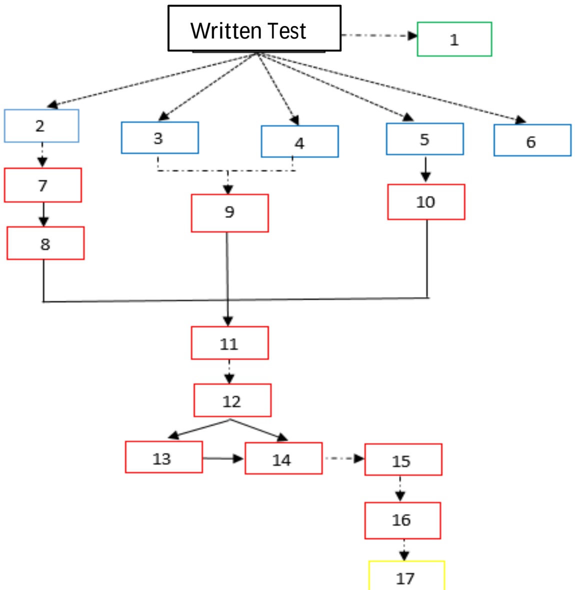

Figure 9. SR_1 Mathematical Connection

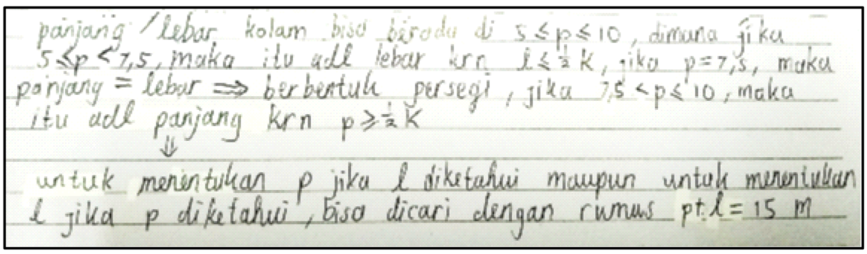

Figure 8. SR_1 Work in Drawing Conclusion

Table 1. Figure 9 Description

Symbol	Description
- - - - - - - -►	1. Translating the size of the rectangle perimeter the catfish pond. 2. Translating the depth of the pond as the height of the pond. 3. Translating the water level from the surface of the pond as the water depth limit in the pond. 4. Converting the minimum volume of water in the pond as the volume of water. 5. Asking the length of the ponds.
- · - · - · ►	1. Making a model or assumption of the perimeter of a pond, pond height, water volume, water length, pond length and pond width. 2. Determining the perimeter formula of the fish pond. 3. Connecting the height of water with the depth of the catfish breeding pond and the height of the water from the surface of the catfish breeding pond. 4. Implementing and writing down the procedure to obtain the results $p^2 - 15p + 50 \leq 0$ 5. Drawing the determination of area (interval). 6. Determining the length interval for catfish ponds which is $5 \leq p \leq 10$ 7. Checking the validity of the $5 \leq p \leq 10$ value by substituting the $175 \leq plt$ inequality
——►	1. Determining the width of catfish breeding ponds by applying and connecting the concepts of linear equations and number operations around the surface of catfish breeding ponds. 2. Connecting the volume of pond water with the concept of inequality, $175 \leq p.l.t$ 3. Relating the relationship between pond length and water height with pond water volume and quadratic equation by substituting $l = 15 - p$ and water height = 3,5 ke $175 \leq p.l.t$ 4. Connecting $p^2 - 15p + 50$ with the quadratic equation to get $p = 10$ or p = 5 5. Determining the interval length of the pool by connecting p = 10 or p = 5, the concept of quadratic inequality, and the number line.
	Understanding problem
	Planning problem-solving approach
	Implementing problem-solving approach
	Rechecking

tained height yields of water in catfish breeding ponds since SR2 considered that there is a relationship between the depth of catfish breeding ponds with the height of the water in the surface of the pond. Therefore, SR2 applied the concept of number reduction operations, reducing the depth of catfish breeding ponds with the height of the water in the surface of the pond to obtain a height water yield = 3.5 m. However, SR2 did not write down the results of the calculations carried out so as to obtain water height = 3.5 m. The results of the sketches made by SR2 are presented in Figure 10.

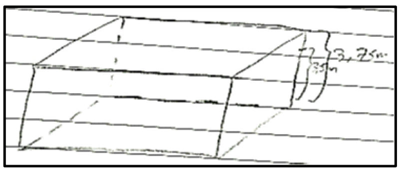

Figure 10. Fishpond Drew by SR_2

The following are the reasons for SR2 in transmitting information obtained from the written test:

Researcher: Today I will interview the results of your work yesterday. Okay, from the written test that you gave, what information is known in the written test?

SA1: What is known from the written test are: the depth of the pool is 3.75 m, the height of the water from the lip of the pond is 0.25 m, the surface of the pond is rectangular with a circumference of 30 m, and the water volume of the pond is at least 175 m^3.

Researcher: Besides that, is there any other information known from the written test?

SA1: There is no ma'am.

Researcher: Try to explain to mother in detail the information that is known from the written test according to your understanding!

SA1: Earlier I explained that the surface of catfish breeding ponds are rectangular in shape with a circumference of 30 m, while the ponds are in the form of rectangular prisms. Then the depth of the pool is the same as the height of the block, ma'am. The volume of pond water is at least 175 m^3. That explains in the pond there is water at least , not less than that, but it can be more than that. Finally the height of the water from the lip of the pond is 0.25 m.

Researcher: What is asked from the written test?

SA1: What is being asked is the long interval in the pond where the catfish farmers breed.

Researcher: Can you explain to the mother what is meant from what was asked?

SA1: It means that it's about the length of the pond where the catfish breeders can be made.

Researcher: Okay, your answer sheet has a description of 3.5 m. What does that mean?

SA1: That's the height of the water, I got it by reducing the height of the rectangular prism with the height of the water from the edge of the pond.

In the next step, SR2 determined the width of catfish breeding ponds by applying and connecting the concepts of linear equations, number operations, and flat shapes about rectangles. Before SR2 applied the concept, SR2 first wrote the information about the surroundings of the catfish breeding pond, perimeter = 30 m. SR2 translated the perimeter of catfish breeding ponds as rectangles perimeter. Then SR2 wrote the formula of the rectangle perimeter that is $2l + 2w = perimeter$. SR2 further applied the concept of linear equations by substituting the perimeter = 30 m into the perimeter formula of the rectangle. Thus, we obtained $l = (15 - p)\ m$. The steps taken by SA1 are presented in Figure 11.

Furthermore, $l = (15 - p)\ m$ and the height of water that SR2 has obtained was substituted into $p.l.t \geq 17$ in order to obtain long intervals of catfish breeding ponds. Furthermore, SR2 did the calculation to obtain $p^2 - 15p + 50 \leq 0$. The results of, were connected by SR2 with the concept of inequality squared. The results of SR2's work are presented in Figure 12.

Furthermore, SR2 connected the concept of quadratic equations with the results of $p^2 - 15p + 50$ that have been obtained. It intended to obtain the length of catfish breeding ponds. The results of the connection performed by SR2 are presented in Figure 13.

After obtaining $(p - 5)(p - 10) \leq 0$, SR2 determined the length interval for catfish breeding ponds. On the answer sheet, it appears that SR2 directly wrote the interval that has been obtained without writing down how to obtain it. After the researchers checked the results of the SR2 answers, it turns out SR2 wrote down how to obtain a long interval. The following are the steps taken by SR2 which is presented in Figure 14.

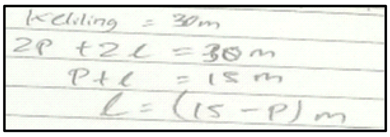

Figure11. SR_2 Work in Determining Pool Width

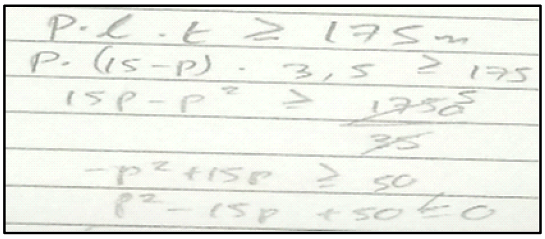

Figure 12. SR_2 Work in Subtituting Pool Width and Water Height

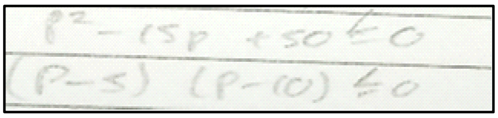

Figure 13. SR_2 Work in Connecting Quadratic Equation

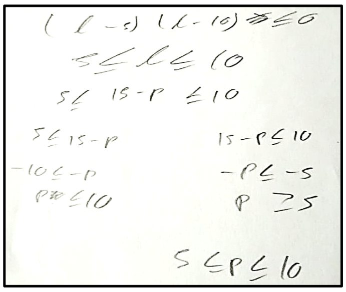

Figure 14. SR_2 Work in Determining Pool Length Interval

The last step taken by SR2 was to write a conclusion from the interval that has been obtained. The conclusion written by SR2 is presented in Figure 15.

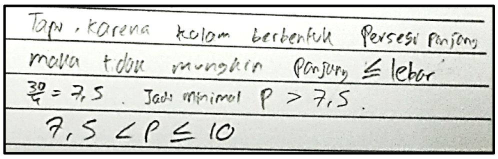

Figure 15. SR_2 in Drawing a Conclusion

In Figure 14, SR2 concluded that $7{,}5 < p \leq 10$. Though, the length concept can be interpreted broadly. Thus, it can be said that SR2 was mistakenly in making conclusions. This can be seen in the following interview results:

Researcher: Are you sure you've answered correctly?

SA_1: Not really Ma'am.

Overall, the following is a description of the SR1 mathematical connection process in solving the written test (Figure 16).

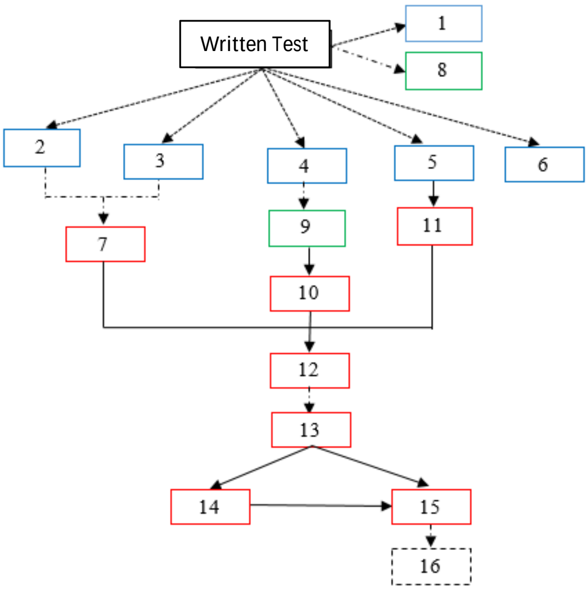

Figure 16. Mathematical Connection of SR_2

Further explanation about Figure 16 is presented in Table 2.

DISCUSSION

Students with rational personality types solve mathematical problems in a longer time than the time given. This is because the subjects wrote a problem solving plan in detail as a guide in solving problems. The response given by two students with rational personality types in solving problems were different. SR1 began to solve the problem by translating the information into mathematical language and writing it on the answer sheet. Whereas, SR2 started by drawing sketches of blocks, translating information in written tests, and providing information. In addition, SR2 applied the concept of number operations to obtain additional information added to the sketch. SR2 did not write what was known and asked on the answer sheet, but when during the interview SR2 could explain and translate information on a written test. Based on this, SR1 and SR2 have fulfilled the components of the process of mathematical connections: translating, describing, and translating.

Next, students with rational personality types make a plan of problem solving by making an example of information on a written test and determining the formulas or concepts. SR1 and SR2 made mathematical models or examples without providing information about what the translation is. However, both could determine that the formula around the rectangle and the volume of the rectangular prism will be used to solve the problem. This is in accordance with the opinion of Muryati and Rahaju (2016) that students with rational personality types do not mention the information obtained but immediately think of an appropriate formula to solve the problem. Formula assumption and determination that will be used in solving problems can be interpreted that the two have fulfilled the components of the mathematical procedure connection process as an equivalent representation and connections between mathematical concepts.

At the stage of implementing the problem solving plan, both applied and connected the concepts of linear equations, number operations, 2-dimensional rectangles, 3-dimensional shapes, quadratic equations, quadratic inequality in order to solve problems. The process by students with this personality type in solving problems until the step is identical. However, both are different when determining pool length intervals. The connection process carried out by SR1 in concluding was correct. While the connection process by SR2 remained incorrect. The association of several mathematical concepts made by SR1 and SR2 can be said that both of them have fulfilled the components of the connection process between mathematical concepts. This is consistent with research con-

Table 2. Figure 16 Description

Symbol	Description
- - - - - - - -▶	1. Translating the problem of catfish ponds as a space that is a rectangular prism. 2. Translating the depth of the pond as the height of the pond. 3. Translating information about the water level from the surface of the pond. 4. Translating the size of the perimeter rectangel as the area of the catfish pond. 5. Translating the least water volume as the minimum volume of water in the pond. 6. Understanding what is asked about the length of the pool interval
- · - · - · ▶	7. Connecting the height of water with the depth of the catfish breeding pond and the height of the water from the lip of the catfish breeding pond. 8. Making a model or assumption of the perimeter of the pond, water volume, pond length, and pond width. 9. Determining the formula around the fish pond. 10. Implementing and writing down the procedure to get the results $p^2 - 15p + 50 \leq 0$Making conclusions regarding the length interval of catfish ponds which is $7,5 < p \leq 10$.
──────▶	7. Determining the width of catfish breeding ponds by applying and connecting the concepts of linear equations and number operations around the surface of catfish breeding ponds. 8. Connecting the pool water volume with the concept of inequality is $V \geq 175$ 9. Relating the relationship between pond length and water height with pond water volume and quadratic equation by substituting $l = 15 - p$ and water height = 3.5 to water volume ≥ 175. 10. Connecting p $p^2 - 15p + 50$ with the quadratic equation to get $p = 10$ or $p = 5$ 11. Determining the length of the pool interval using the fast method
(blue box)	Understanding problem
(green box)	Planning problem-solving approach
(red box)	Implementing problem-solving approach
(dashed box)	Rechecking

ducted by Prasetyo et al (2017) which says that rational students can find relationships of various mathematical concepts and procedures, as well as understanding the relationships between mathematical concepts. SR2 did not re-examine the answer results. This is in accordance with Prihati and Wijayanti (2017) and Muyassaroh (2017) which say that students with rational personality types are not able to re-examine the results of work that have been obtained.

Overall, the connection process made by students with rational personality types is complete, according to the characteristics of individuals who have rational personality types proposed by Keirsey (1998). Keirsey (1998) states that individuals with rational types have skills in connecting and communicating well. In accordance with the results of the exposure which states that students with rational personality types are able to translate and convey information obtained from the given problem. In addition, in the interview process students with rational personality types can convey the process taken and also relate the information obtained to solve the problem.

CONCLUSION

Based on the results and discussion, The process of mathematical connections made by students with rational personality types is complete. This is because students of this personality type meet all components of the mathematical connection indicator. Furthermore, the connection process between mathematical concepts undertaken by students with rational personality types is incomplete. The reason this process is incomplete is because students from both personality types do not fulfill one component out of the six components in the connection indicator between mathematical concepts. The component that is not fulfilled is linking the width of the catfish breeding pond to the volume of water in the step of re-checking. While the connection process of mathematical procedures as an equivalent representation of students with rational personality types is not yet complete. This process is incomplete since it does not meet the two components of the mathematical procedure connection indicator as an equivalent representation.

Based on the conclusion above, students are expected to be able to study Mathematics in depth so that the mathematical connection process is complete. Whereas for teachers before learning, it is better to choose a learning model that can improve students' mathematical connection abilities thus it impacts on the connection process and gives students time to continue practicing in solving problems.

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