



Exploration of Relational Thinking Skills Using Problem Solving of Geometry Transformation

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Abstract

The aimed study is analyzing the mathematical ability of students with relational thinking skills in geometry transformation material. This study used a descriptive qualitative approach. Data collection techniques were carried out by giving tests based on contextual problems and interviews. The test result was used to measure the effectiveness and completeness of learning outcomes. Furthermore, the result of the interviews supported the data of test results and identified the problem that was faced during the process of the test. The research showed that the most achieved indicator is the first indicator which can write the important information and create the relation about the description of the problem. Meanwhile, the least indicator that has been achieved was the third and fourth indicator which analyzed the relation by using structures, symbols, and properties to find models and re-check in the form of sketching and operating matrices transformation.

Abstrak

Tujuan dari penelitian ini yaitu "mengkaji kemampuan matematis peserta didik dengan relational thinking skill pada materi transformasi geometri". Penelitian ini menggunakan deskriptif dengan pendekatan kualitatif. Teknik pengumpulan data dilakukan dengan memberikan soal tes berbasis permasalahan kontekstual dan wawancara. Hasil test digunakan untuk mengukur keefektifan dan ketuntasan hasil belajar. Selanjutnya hasil wawancara mendukung data dari hasil tes dan mengidentifikasi masalah yang dihadapi selama proses tes. Hasil penelitian menunjukkan bahwa Indikator yang paling banyak dicapai yaitu indikator pertama yang mana mampu menuliskan informasi penting dan membentuk relasi tentang gambaran sebuah masalah. Sementara itu, indikator yang paling sedikit dicapai adalah indikator ketiga dan keempat yang mana menganalisis relasi dengan menggunakan struktur, simbol, dan sifat untuk mencari model dan mengecek kembali dalam bentuk sketsa dan operasi transformasi matriks.

Keywords: relational thinking skills, problem solving, geometry transformation, junior high school

INTRODUCTION

Mathematics is a disciplines for the other knowledge (Sopian & Afriansyah, 2017). A lot of concepts in mathematics that has an

important role in education, also in our daily life (Etrina, Anriani N., & Fathurrohman, 2018). One of the material of geometry can be applied in our daily activities (Indrayany & Lestari, 2019). Material of

geometry are considered important to learn, because its able to increase the students skills in mathematics (Luvy Sylviana Zanthu, 2020). Mathematics is one of the important tool to develop the pattern of thinking skills and to solve the students problems in their life for sure (Kızıltoprak & Köse, 2017). This case can be seen from the result of mathematics study that capable to increase the comprehension and holistic of the students, also able to finish a cross topic or field of study with another material (Prasasti Abrar, 2016).

The result of observation made by Jamalun & Suhar (2016) stated that mathematics learning in school actually has limitation time and some of students assume that mathematics are very tense, unsettling and do not has relation of their daily activities. Many of students just memorize the formula without pay attention and understand the concept in mathematics (Jamalun & Suhar, 2016). Based on Inganah et al (2016) students just clever in applications the mathematics formulas, but didn't get the beginning of the sources of mathematics formulas. This case strengthened by the result of investigation from Etrina, Anriani N., & Fathurrohman (2018) that stated that from the mathematics learning, the result can be said still low. In mathematics learning, maybe still many mistakes that has made by the students about the concepts, operations, structures and principle when solving problems in story tests (Zahra' Ashri and Aini, 2021). Some of the students still have difficulties in solving a story tests that related to geometry (Magfirah et al., 2019). The problem of learning in geometry transformation that based on the result of interviews which contained in journal article is the students have not been able to draw of transformed objects (Elvi et al., 2021), so the students concluded that geometry transformation are difficult (Maulani & Setiawan, 2021).

Based on Baiduri (2019) the teacher skills to connect the mathematics with real life has being one of the aspect of skill that must be in character of the teacher while teaching in class.

The observation of Utami and friends (2020) mentioned that mathematics learning by using online system can inflict the students cannot understand the material maximally, students get many tasks but there is technical disturbance like the internet connection that hinder their understanding, and also the complexity of using of the e-learning application. This thing has opposite of the research of Agustina (2020) and Setyadi & Qohar (2017) that mentioned that online learning should can be increase the learning autonomy of the students, by digging information about the material and task that has given by teacher by doing some activities, for instance reading some books or online module, discussion with friends of the same age by using e-learning application then try to do it. This case also supported by research from Prio baskoro (2013) that said that students more active and excited in mathematics learning by using online system and accompanied by the role of the teacher as an effective facilitator.

The concept of technology information has been characteristic of learning in 21-st century in shape of online learning, because it has high prospect and take effect in learning process, one of them is mathematics learning (Darmawijoyo, 2011) and also in case of education on 21-st century has demand the students to able to compete in global (Hidayah et al, 2017). Technology is a best facility to support the developing the potency of learn in mathematics learning, because it is able to give or exploring the scope of material extensively (Kulsum et al, 2020). Technology also contributes as a crutch of the

teacher in drafting and evaluating the students (Ummah, 2018). 21-st century has given a total change in public or in education world, the characteristic of 21-st century that the most dominant is more stronger of the discipline of knowledge skill, so the interaction of them will be more fast and balance (Wijaya et al, 2016). The claim content of 21-st century's learning based on Etrina, Anriani N., & Fathurrohman (2018) on mathematics skill is demand the students to be more quality and has comparative skill, innovative, competitive, then able to collaborate their skill, so they can customize of the cange of era, because students are not only study and take control of mathematics meaningfully, but they also can do the critical thinking, creative and adaptive on learning (Effendi, 2019). Besides of demand on the research from Redhana (2019) stated that 21-st century has introduced the skill that named as 4Cs, that are covering critical thinking, creativity, communication, and collaboration. Not only that, the observation of Syahputra (2019) added about the skill that must have by the students on 21-st century's learning is creativity and innovation, observation and fluency of information, critical thinking, problem solving and making decision, digital citizenship, technology operation and concept. One of the benefit of the creativity on mathematics learning is can improve the student's knowledge (Ummah et al, 2019).

Thinking and problem solving are the things that cannot be separated and very related each other, thinking is an effort which conducted to find or solve the problem that faced by students, whereas problem solving is the one thing that must be conducted when delivering the solution that founded on facts that closely related to mathematics problem (Prasasti Abrar, 2016) and one of the purpose of mathematics learning (Baiduri, 2015). The

level of thinking of the students has different when they solve a problem, both in formulating and working on information that associated with their learning experience (Oesmolos et al, 2019). The problem solving skill has connection to any factors, that are variety of problems, problem presentation till problem solving and the difference of critical thinking by the students (Baiduri, 2015). Therefore thinking and problem solving has been an important aspect in mathematics learning skill (Susanto & Permadi, 2019).

Based on Baykul in (Peranginangin & Surya, 2017) problem is a case that has founded and faced, it is important and must be solved, likewise if the problem applied on learning, students must have skill in solving a problem to solve that problem that has given by the teacher in school. Problem solving has important role on mathematics learning in the education unit (Tambunan, 2019). Problem solving is the main method in general purpose and the focus on mathematics learning that link the visualization, imagination, abstraction, and information association, because the problem solving of the students can be helped in increasing and developing their skill in application aspect, analysis, synthesis, and evaluation (Rahman & Ahmar, 2016). When solving a problem in mathematics learning, students who has relational thinking skills will be easier to solve the difficult problems (Pradika et al., 2019). Pehkonen in (Peranginangin & Surya, 2017) has collecting four categories, the important reason is to guide and practice a problem solving, that are a) problem solving are capable to increase the general cognitive skill, b) problem solving are able to help on developing of creativity, c) problem solving is a component of the process of applying mathematics, and d) problem solving can increasing, developing the skill, also giv-

ing motivation to students to learn mathematics.

The learning process in education world on 21-st century needs an ability that focus on skills, one of them is *relational thinking skill* (Susilawati et al, 2018). Therefore, it is important to increase *relational thinking skill* in mathematics learning, specifically to study of geometry transformation in junior high school. *Relational thinking skill* are used to arrange the relation in various kinds of object or context that bound each other in mathematics (Kurniawan & Rudhito, 2016). Therefore, the basic concepts in mathematics are very broad, containing the relation between different representations ranging from the number, operation number with the object (Tafrilyanto, 2016). Through empowerment procedure *relational thinking skill* be expected can increasing the ability in problem solving of geometry transformation in junior high school (Santia dkk, 2018). For the outline, students that able to think rationally will be easier to solve the difficult problem (Pradika dkk, 2019). Based on Tafrilyanto (2016) students are able to plan to solve the matter/problem well through the process of *relational thinking skill*. Kızıltoprak & Köse (2017) revealed in his research that there is an interaction of developing basic arithmetic concepts and algebraic thinking with relational thinking skills so that through web-based professional development programs and training in services they can emphasize the role of using *relational thinking skill*. This case has been a contradictory with the result of research of Hidayah dkk (2017) which states that mathematics learning in the 21-st century emphasizes critical thinking skills. Students are rather than relational thinking skills, even teachers do not understand how to measure their abilities in *relational thinking skill*.

Wantika (2019) stated that in her

observation that through the result from interview-based test in trigonometry function with indicator ability of *relational thinking skill*, students are able to represent in detail to understand the problem solving in mathematics. The research of Kulsum dkk (2020) stated that through observation sheets, interview guidelines, student worksheets and test questions in the form of worksheets, students' relational thinking skills increased and were very good at connecting the concept of gradient and limit h to zero with the concept of derivative functions with the help of Geometer's sketchpad software. This case also has supported by the research of Santia et al (2018) which stated that the using of algebra module based on *relational thinking skill*, students are able to increase their ability in problem solving of algebra material.

Based on analysis above, the thing that can be the difference than the research before is, this research is focused on describing the result of exploration in relational thinking skill of the students in problem solving of geometry transformation through by giving test questions that based on visual type – contextual. The purpose of this research is to "Analyze the mathematical ability of students with relational thinking skills in 21st-century learning, also to solve the mathematical problems in geometry transformation material in junior high school". In 21st century learning which means in this study is the use of technology in learning to solve mathematical problems in the form of learning media that based on android. In this research, there is benefit that through the relational thinking skill, students are able to describe the planning of problem solving in geometry transformation with properly and correctly (Darsono et al., 2018; Jatmiko, 2016; Wantika, 2019).

METHOD

The exploration of *relational thinking skill* in problem solving of transformation above can be said as descriptive research that using qualitative approach. This approach uses to gain the description about the issue that has gotten by the students in their ability in *relational thinking skill* while finish the task of geometry transformation (Kurniawan & Rudhito, 2016). The data in this study were obtained from several instruments, namely geometry transformation test questions based on contextual problems, interview guidelines that be adapted to indicators of relational thinking skills and validation sheets (test questions and interview guidelines with indicators of relational thinking skills). The preparation of test questions in the form of essay questions with the aim of making it easier for researchers to know students in the use of relational thinking skills. The test questions compiled will also be validated by mathematics education lecturers and teachers at MtsN 7 Kediri.

This research has implemented in MtsN 7 Kediri for students who in grade 8 D class. The research subject has taken of 10 students as a limited trial that based on research of Sadiman (Jatmiko, 2016) stated that the trial of the small group there are 10-20 students. The ten test subjects were selected randomly by using simple technique of random sampling and have characteristics, including the highest final test score in their class, have clearly legible writing, can explain in a straightforward and logical manner, and representing each class.

The technique of collecting data has done by the research that used before is kind of empirical research till the technique of collecting data in this research is by the validation questionnaire test, the

test questions for the description of geometry transformation that based on contextual problems and interviews. Validation questionnaires are used to measure of the validity of learning device, while the results of post-test of the students are used to measure the effectiveness and completeness of learning outcomes. Furthermore, the results of student interviews are used as reinforcement the results data of the test and to find out the problems that faced during the process of working on the test questions. In this study, there are two kinds of data, that is test results data and interview results. The test result data is categorized based on the percentage of achievement of the relational thinking skill indicator on the appearance of students' answers as shown in Table 1.

Table 1 Categorization of Students Based on Achievement Indicators of relational thinking skills

Achievement percentage	Category
$0 \leq P \leq 40$	Low
$40 < P \leq 80$	Medium
$80 < P \leq 100$	High

Furthermore, the subject of the interview was selected by one student in each low, medium, and high category. The data analysis that used in this study is qualitative. The data from the test results and student interviews were analyzed by using descriptive method. The first step, the test result data is given comments as evidence of the suitability of students' answers with indicators of relational thinking skills. The second step is data reduction where the test result data is grouped according to high, medium, and low categories, while the interview data is grouped based on the occurrence of keywords in each relational thinking skill indicator. The third stage is data verification where the researcher cross-checks the suitability

of the test results with the interview results. The fourth stage is presenting data by displaying scanned student answers that have been given the appropriate indicator marks for relational thinking skills followed by the results of interviews obtained, whether they support student answers or not. The fifth stage is drawing conclusions from all the data obtained, namely in the form of exposing which indicators of relational thinking skills have been achieved by students from the results of tests and interviews along with evidence and reasons. The indicators for relational thinking skills adapted from (Tafriyanto, 2016; Wardani & Susannah, 2020) as shown in the Table 2.

Table 2: Indicators of Relational Thinking in Problem Solving

Polya's Stages	Relational thinking skill Activities	Achievement Indicators
1. Reading/Understanding the problems	a. Build a relation based on the elements of linkage information in the problem or prior knowledge b. Build/create an appropriate picture of the problem or operation in his mind	Students are able to build relationships based on the most important elements of linkage information in understanding the problem or prior knowledge in his mind appropriate
2. Make a plan /choose strategy	a. Build/analyze relation by using structure and find strategies in solving problems b. Build a relation that based on information in a problem based on prior knowledge	Students are able to build/make relationships by using structures, symbols and properties to develop strategies in solving problems
3. Implementation plans	a. Build/analyze a relation by using structure and find strategies in problem solving b. Build a relation based on information in a problem based on prior knowledge	Students are able to build/analyze relationships by using structures, symbols and properties to find models and implementation strategies in solving problems

Polya's Stages	Relational thinking skill Activities	Achievement Indicators
4. Re-check	a. Build a relation based on information in a problem based on prior knowledge b. Analyze the use of operating structures when checking back	Students are able to analyze the use of operating structures when checking back

Furthermore, to obtain data, the researchers conducted a test of geometry transformation questions in the form of a description of the geometry transformation test questions based on contextual problems accompanied by interview guidelines based on the test answers of 10 students of MTsN 7 Kediri. Then to find out the results of the validity of the test questions, validation sheets were given to the mathematics education lecturers and teachers of MTsN 7 Kediri by doing a cross check using a score calculation according to the Likert Scale with a description of the rating scale, namely "5" was very good, "4" was good, "3" is quite good, "2" is not good, and "1" is very bad. The Rubik made contains indicators of relational thinking skills on the geometry transformation test using the formula:

$$\frac{\text{Subject Scores}}{\text{Overall Scores}} \times 100\%$$

The results of validation of the test questions were categorized as very valid with a percentage of 80.5% and the results of validation of the interview guidelines were categorized as valid with a percentage of 78%.

RESULT AND DISCUSSION

Research result

Observation was carried out for two weeks, which started on March 20th 2021 till april 3rd 2021. The subject of this research is 10 students for 8 grade of D class from MtsN 7 Kediri that has chosen and

has the characteristic that is the higher score of final tests in his/her class, has clearly legible writing, has the ability to explain clearly and logically, and represent each class. The results of the study through test questions, descriptions of geometry transformations based on contextual problems and interviews based on each indicator of low, medium, and high answers stated that 10 students of class VIII D MTsN 7 Kediri were less able to use relational thinking skills with indicators of problem-solving stages according to Polya.

Representation process by the students who has the highest final test scores

Students who have the highest UAS scores, namely AN (abbreviation of student names) can meet all the indicators of relational thinking skills as we can see at table 2 and present and describe the meaning of the questions into the results of their work. Based on the AN answer sheet in Figure 1, AN can determine the shape of the rotation matrix transformation with a center point (0,0) of a. This shows that AN can define and solve a given mathematical problem.

1.) Bayangan mobil $P(a,b)$ yang bertitik pusat $(0,0)$ sebesar -90° dengan tempat pertama $P'(-10,-2)$. Dit: $a+2b$?

Jawab =

Rotasi dengan pusat $(0,0)$ sebesar a

$$A' = \begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos a & -\sin a \\ \sin a & \cos a \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

dengan $x' = -10, y' = a, y = b$, dan $a = -90^\circ$ maka

$$P' = \begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} \cos(-90^\circ) & -\sin(-90^\circ) \\ \sin(-90^\circ) & \cos(-90^\circ) \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

Figure 1.a

1.) Car shadow $P(a,b)$ dotted $(0,0)$ as big as -90° of first place $P'(-10,-2)$. Dit: $a+2b$?

answer =

rotation of center $(0,0)$ as big as a

$$A' = \begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos a & -\sin a \\ \sin a & \cos a \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

with $x' = -10, y' = a, y = b$, dan $a = -90^\circ$ so

$$P' = \begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} \cos(-90^\circ) & -\sin(-90^\circ) \\ \sin(-90^\circ) & \cos(-90^\circ) \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

Figure 1.b. Translate of Figure 1.a.

Figure 1. The results of the AN test in understanding the problem and determining the relation of using the structure

Based on figure 1, it showed that students are able to control the ability of rational thinking to understand a problem, where AN is able to build the linkages all of the problems and finding an important elements in question, so AN is able to write completely that already knew and requested by the question that cover the location of the startingpoint of car before rotated with the central point (0,0) as big as -90° . Furthermore, AN stated that the image point of the car is located at $P'(-10,-2)$ which will be rotated with the center point (0,0) with an angle of -90° which will be written as initial information on the work.

After AN conveys the overall Figure of the information obtained, then the AN analyzes the next step in determining the plan that will be used during the work in making the answer decision.

ingat sudut negatif

$$\sin(-a) = -\sin a$$

$$\cos(-a) = \cos a$$

$$\tan(-a) = -\tan a$$

Sehingga

$$P' = \begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} \cos 90^\circ & -\sin 90^\circ \\ -\sin 90^\circ & \cos 90^\circ \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} \cos 90^\circ & \sin 90^\circ \\ -\sin 90^\circ & \cos 90^\circ \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

Figure 2.a

remember the negative angle

$$\sin(-a) = -\sin a$$

$$\cos(-a) = \cos a$$

$$\tan(-a) = -\tan a$$

so that

$$P' = \begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} \cos 90^\circ & -\sin 90^\circ \\ -\sin 90^\circ & \cos 90^\circ \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} \cos 90^\circ & \sin 90^\circ \\ -\sin 90^\circ & \cos 90^\circ \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} a+b \\ -a+b \end{pmatrix}$$

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} b \\ -a \end{pmatrix}$$

Figure 2.b. Translate of Figure 2.a.

Figure 2. Making plans based on information in a problem based on prior knowledge

Based on Figure 2, AN analyzes by selecting a strategy at the stage of planning. AN is able to make geometric transformation shapes and determine the value of the angle based on the previously known information. So AN is able to write the rotation of transformation formula of the center point (0,0) with an angle of $a = -90^\circ$ and $P'(-10, -2)$ as the image of point of the car. Then, AN can build and analyze a plan and link relationships by using algebraic operations and substituting information obtained from previously knowledge. Next is a **Figure** of the results of the AN test in carrying out the plan / working on the questions

$$\begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} b \\ -a \end{pmatrix}$$

diperoleh

$$b = -10$$

$$-2 = -a \longrightarrow a = 2$$

Nilai $a + 2b = 2 + 2(-10)$

$$= 2 - 20$$

$$= -18$$

jadi nilai $a + 2b = -18$

Figure 3.a

obtained

$$b = -10$$

$$-2 = -a \longrightarrow a = 2$$

$$\text{score } a + 2b = 2 + 2(-10)$$

$$= 2 - 20$$

$$= -18$$

$$\text{to be score } a + 2b = -18$$

Figure 3.b. Translate of Figure 3.a.

Figure 3. Do the plan find the result of score with analyze the operation structure, also to connect the strategy of problem solving based on information from the knowledge before.

Based on Figure 3, the step of AN in analyzing the operation structure to implement the plan that has chosen when get the early information from questions. AN determines the final score requested by the question after AN crosscheck the answer again. However, in the third stage of Polya, AN is not good at implementing plans which include activities to build/analyze relationships using structures and implement strategies in solving problems and building relationships based on information in a problem based on prior knowledge. Based on the result of AN's interview which has revealed the problem that faced by AN, that is AN got a problem about the operation of matrix multiplication, so it needs to read for 3 times to remember the operation of matrix multiplication. After finding the results of the scores requested, AN also did not forget to cross-check the answers, AN linked the information obtained with the results of the scores obtained to check whether the answers obtained were correct with the questions asked in the questions. So that AN's relational thinking skills appear when AN evaluates the results of the answer decisions by rereading the questions, re-

checking the steps that have been used and recalculating the answers.

Representation of process that has done by students who has easy to read writing.

Students who have easy to read writing is AS (the short name of student). AS is good to understand a problem, but not good in writing of the shape of matrix transformation and less in planning as shown in the Figure 4.

$$\begin{array}{l} \square 1. \begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \alpha & -\sin \alpha \\ -\sin \alpha & \cos \alpha \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix} \\ \square \\ \square \\ \square \begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix} \\ \square \\ \square \end{array}$$

Figure 4. The result of AS's test in understanding of problem and determine the relation by using structure

Based on the result of the interview, AS is able to read a problem and disclose that has known as an early information in working test. AS said that the angle of $\alpha = -90^\circ$ and the image point of the car, namely $P'(-10, -2)$ which is also rotated with the center point $(0, 0)$ can be used as initial information for working on the problem, so that AS is able to form an equation which is shown in Figure 4. However, AS is not good at writing and constructing a form of linkage from the information obtained. So that in the next step to determine the results of the values of a and b , AS is not good.

The AS's steps in carrying out the plan can be shown on Figure 5.

$$\begin{array}{l} \square a = -10 \\ \square b = -2 \\ \square a + 2b = -10 + 2(-2) \\ \square = -10 + (-4) \\ \square = -14 \end{array}$$

Figure 5. Implementation the plan in search of the result of score by analyzing the operation structure and connecting the problem-solving strategy based on information on the knowledge before

Based on Figure 5, AS is not capable in implementing and executing the strategy that has made before, because AS got a problem when operating the multiplication, so AS just operating the multiplication from matrix that has written and AS not able to finish the problem appropriately, according to assumptions that has written in problem solving, also didn't do crosscheck the answer anymore.

The representation process carried out by students can explain in a straightforward and logical manner, and represents each class

Students who can explain in a straightforward and logical manner, and represent each class is HA (short name of student). HA meets the three indicators of relational thinking skills with the problem-solving stages according to Polya, because HA is not good at re-examining the answers, because there are small and careless errors. In Figure 6, HA can determine and write the form of the rotation matrix transformation equation with the center point $(0, 0)$.

$$\begin{array}{l} \square \\ \square 1. \begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \alpha & -\sin \alpha \\ \sin \alpha & \cos \alpha \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \\ \square \\ \square \begin{pmatrix} -10 \\ -2 \end{pmatrix} = \begin{pmatrix} -\cos 90^\circ & \sin 90^\circ \\ -\sin 90^\circ & -\cos 90^\circ \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \\ \square \end{array}$$

Figure 6. The result test of HA in understanding a problem and determine the relation by using a structure

Based on the result of interview, HA can build the relation by express the information based on the problem on the questions. HA said that there is a rotation matrix equation with a center $(0, 0)$ and an angle of $\alpha = -90^\circ$, then the car's image point is at point $P'(-10, -2)$.

The step of HA in making and implementation of plan can be seen on Figure 7.

$$\begin{aligned} \left(\begin{array}{c} -10 \\ -2 \end{array} \right) &= \left(\begin{array}{cc} 0 & 1 \\ -1 & 0 \end{array} \right) \left(\begin{array}{c} x \\ y \end{array} \right) \\ \left(\begin{array}{c} -10 \\ -2 \end{array} \right) &= \left(\begin{array}{c} y \\ x \end{array} \right) \\ y &= b = -10 \\ x &= a = -2 \\ a + 2b &= -2 + 2(-10) \\ &= -22 \end{aligned}$$

Figure 7. Implementation the plan in searching of the result of score by analyzing the structure operation and connecting the strategy of problem solving based on the knowledge before

Based on Figure 7 above, that case has showed that HA is able to analyze the relation that using operation structure while doing the plan and strategy that has chosen to solve problem, HA is able to operate multiplication on its transformation until it finds the result of the value requested in the problem. However, HA is not good at analyzing the use of operating structures when re-examining, because HA feels confident that the answers, he has obtained are correct, so there are small and inaccurate errors.

Discussion

The result of this research are supporting and has a similarity to previous research, where the research that has done (Kurniawan & Rudhito, 2016) dan (Wantika, 2019) are using descriptive research methods with a qualitative approach and research instruments in the form of Contextual Mathematics test questions, and Interview Guidelines based on students' test results. As for the differences in data analysis techniques in previous studies, with this study, research Kurniawan & Rudhito (2016) are using analyze technique by qualitative then serve the data by narrative and research Wantika (2019) is using analytical techniques, namely data reduction, data presentation, drawing conclusions, while in this study using qualitative descriptive data analysis techniques. The

use of test questions based on relational thinking skills indicators can improve the ability and understanding of students in mathematical problems (Wantika, 2019). Moreover, one of the research instrument that is interview guidelines also able to increase the ability which is *relational thinking skill* of the students to connect any mathematics concept (Kulsum et al., 2020). To measure indicator of thinking skill is by using steps the problem solving based on Polya. Based on the problem-solving steps according to Polya there are 4 stages, in the first stage, namely reading / understanding the problem by containing two relational thinking skill activities, first interpreting the problem by determining the important elements in the problem, second creating relationships within each element and between elements, and form relationships about the picture of the problem. The second step is making a plan/choose the strategy that contains two activities of rational thinking skill, first is building/analyze the relation by using a structure and finding a strategy in problem solving, the second is build a relation based on information in a problem and based on knowledge before. The third is implementing the plan containing two relational thinking skill activities, firstly building/analyzing relationships using structures and finding strategies in solving problems, secondly building relationships based on information in a problem based on previous knowledge. The fourth stage of re-examination contains two relational thinking skill activities, firstly building relationships based on information in a problem based on previous knowledge, secondly analyzing the use of operating structures when re-examining. AN (the student who has the highest score in final test) is better in understand and read a problem, because can elaborate and explain the meaning that has given on question, and still classified then fulfil all

of the indicators of relational thinking skill that are reading/understanding a problem, make a plan/choose a strategy, implementation a plan, and also re-checking.

Based on the results of the research that has outlined above, the following conditions were obtained (see Figure 8).

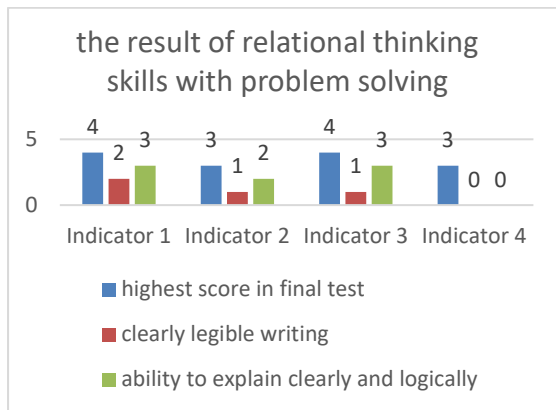


Figure 8. The Result of recapitulation chart

As we know from the diagram above and based on results of confirmation by interviews, it can be said that AN (students who has the highest score in final test) is very well in understanding and reading a problem, because AN is able to describe and explain the meaning given to the questions, and are still classified as fulfil of all the indicators of relational thinking skills with the stages of problem solving, namely Read/understand the problem, Make a plan/choose a strategy, Implement the plan, and also re-checking.

So, it can be concluded that AN can think relationally by fulfil all the indicators of relational thinking skills by the step of problem solving based on on Polya. This case is in line with the opinion of Carpenter et al and Stephens, A in (Delviera Lukita Wardani, 2020) which suggests that students can think relationally when solving a problem by giving logical and rational opinion in every step.

AS (the student who has clearly legible writing) is quite good at understanding a problem. However, AS is not good at

making plan/choosing a strategy, and not good at implementing plan and not checking the results of the answers that has obtained.

As we know that from the result of the diagram and confirmation by interviews, AS can build relation based on the element of information that related to the problem or the knowledge before. However, AS in building the plan that will be used is less precise when writing the formula, so in carrying out the plan, AS is not good in understanding it. AS also did not re-check the result in taking decision from the final score with the questions asked about. So the analyze is in line with research (Tatak et al., 2016) that students who are habitual in using the concept of counting from the teacher will find it difficult to think rationally.

HA (thes tudent who can explain clearly and logically and represent of every class) is very well in understanding and reading a problem, both in arranging a plan to be used and implementing plans. But less in re-checking.

Based on the diagram above and from the result of confirmation by interviews, HA can describe and explain the meaning of the problem in all the questions very well. Also, HA is very well in planning/choosing a strategy and also good in implementing of planned strategy by building and analyzing the relation based on information in a problem that based on previous knowledge. However, HA is not good at re-checking the result of the answer. So this case in line with research (Hadiyanto, 2019) which stated that one of the mistake often made by students is in applying the strategy that has been chosen as well as writing and checking the results obtained.

CONCLUSION

The most indicator that achieved by students is the first indicator in problem solving according to Polya, that are reading / understanding the problem by containing of two relational thinking skills activities, first interpreting the problem by determining the important elements the, second is creating a relation in each elements, and forming a relation about the picture of the problem as a whole, so the students are able to state the information that has known by the formulations of the rotation.

The indicators that are least achieved by students are the third that is build/analyze the relation by using structures, symbols and properties to find models and implement strategies in solving problems and indicators, and the fourth indicators of relational thinking skills is analyze the use of the operation structures when re-check in implementing a plan and checking the re-check the answers, based on test answers and student interviews, there are many errors in writing and applying process skills, where are the students are less able to analyze relationships by using the structure and finding strategies in problem solving based on previous knowledge, then the results of the final answer are less precise and students do not re-check the answers obtained. From all the test results of students, we can see that the researchers can conclude that students still has difficulties in implementing relational thinking skills to solve a problem on visual-contextual problems in geometry transformation material.

Based on the explanation, it is recommended for further research to be more visualize the geometry transformation test questions based on visual-contextual problems accompanied by the provision of problem simulations. And it is also necessary to develop a lesson plan that supports relational thinking skill-

based learning for students on cognitive realm that contains the activity of rational thinking skill in problem solving of mathematics.

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