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Capturing Translation Representation Schema of Students Through Ill-Structured Problems Task

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ABSTRACT

Translation of mathematical representation is one of the important aspects of mathematics problem solving because the accuracy of mathematical representation translation is one of the terms of success in solving a problem. This research purposed to explore how the schema of mathematical representation translation among multiple representations type of junior high school students in solving well-structured problems and ill-structured problems. The participants were 132 8th students in Junior High School (SMP) in Kediri. The participant was then taken two students who completed a step for solving the problems as subjects. This study used qualitative explorative methods, with researchers conducting in-depth interviews with subjects to explore mathematical representation translation processed when solving well-ill social arithmetic problems. Data were analyzed by technique triangulation. Based on data analysis, the researchers found that: 1) both subjects failed to solve ill-structured problems because their translation of mathematical representation didn't accurate. Subject-1 can't unpack the source when problem representation. While subject-2 can't determine equivalence between source representation and target representation, and 2) they found that both subjects have inconsistent representation translation schematic when solving an ill-structured problem. From the founded, the researcher concluded that ill-structured problems must often be given to students to practice their representation translation capabilities.

Keywords: *Translation, Mathematical Representation, Ill-Structured Problem Solving*

INTRODUCTION

Mathematical representation is one of the mathematical skills and important aspects of mathematics learning [1]. This is because mathematical representation is a representation of mathematical ideas that are displayed by someone when they do mathematics learning. These displays can be oral language, written language, symbols, images, diagrams, models, or concrete objects [2-4]. Mathematical representation is one of the determinants of a student's success when constructing mathematical concepts and solving mathematical problems [5]. Research related to the importance of representation in mathematics was also carried out by other researchers. The study found that students' representational abilities were the key to success in understanding mathematical concepts and solving problems [2,5,6].

Regarding the importance of the mathematical representation described above, one form of problem that supports the use of various types of mathematical representations is ill-structured problems. Ill-structured problems are the kinds of problems that are conflicting goals, multiple solution methods, unanticipated problems, distributed knowledge, collaborative activity systems, and multiple forms of problem representation [7]. Ill-structured problems contain authenticity, complexity, and openness [8-10]. The complexities made multiple problem representations and many solutions for this problem. While the nature of authenticity allows the problem to be found in the environment around the individual. Ill-structured problems can also be considered as a way to improve students' mathematical thinking capability because non-routine problems make students associate abstract mathematical knowledge with everyday life. Accordingly, they can recognize information with multiple representations [8]. Ill-structured problems have different stages of solving problems with the stages of solving well-structured problems such as problem representation, developing solutions, making justification, and evaluation [9,11].

Related to the ill-structured problem above, The Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) show that Indonesian students have difficulty solving problems that connect mathematical concepts with everyday life like an ill-structured problem. The results of the last PISA and TIMSS pointed to a low rank for Indonesia (i.e., 62nd in the PISA and 50th in the TIMMS). Indonesian students had 386 mathematics scores. Similarly, they were lower than the international average one (500) [10]. This means that Indonesian student has still possessed some problems in mathematics problem-solving. They possess a lower ability than students of other countries to apply mathematics in general. This is partly due to the use of inappropriate mathematical representations between abstract ideas and their representatives [11], and also the translation between two or more two different representation types didn't accurate [12]. Therefore this study uses ill-structured problems to describe the mathematical representation translation schema that captures when junior high school students solve an ill-structured problem.

Translation is a psychological process involved in going from one type of representation to another [13]. It means the translation process is a changing process from one representation type to another. The translation is a cognitive process and relation from one representation type to another different representation type, without changing the notation object [14,15], and then the translation divided into two categories. They are processing and conversing [14]. Processing is a translation between the same representation type. Meanwhile, conversing is a translation between two or more two different representation types. The translation term used in this research refers to the conversing process, which is transforming between different representations in solving mathematical ill-structured problems. Bosse et al, in their study on students 15 to 17 years old found that there are four activities done by the students in doing translation from the graph to the symbolic [15]. The activities are unpacking the source, preliminary coordination, constructing the targets, and determining equivalence. Bosse suggests that further studies, about mathematical representation translation besides the graph to the symbolic, are also needed in completing the research to examine in more detail the translation process.

To describe the mathematical representation translation in this research, we took into account the following types of mathematical representations: 1) verbal representation of the ill-structured problems: consisting fundamentally of ill-structured problems as stated, whether in writing or spoken (Vb); 2) visual representation: consisting of drawings, diagrams or graphs, as well as any kind of related action (Vs); and 3) symbolic representation, consisting of numbers, operation and relation signs; algebraic symbols, and any kind of action referring to these (Sb).

MATERIALS & METHODS

The research was held in Junior High School in Kediri with 132 participants from 8th students. Bellow Figure 1 is the participants' general information.

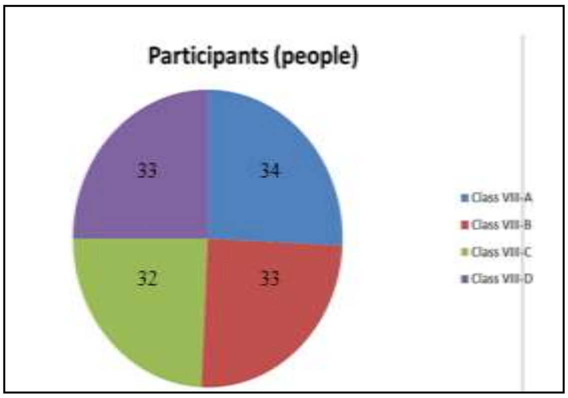

FIGURE 1. Participans' General Information

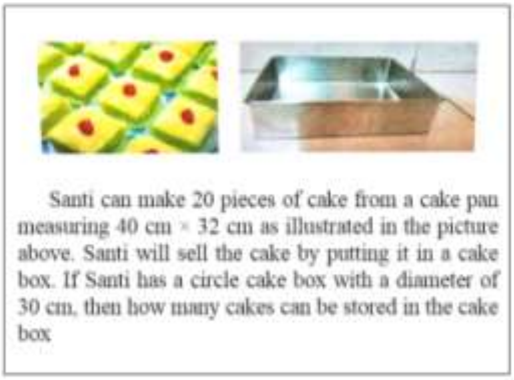

FIGURE 2. An Ill Structured Problem

Then every participant is given the test of an ill-structured problem as in Figure 2. These problems are not familiar to participants, however, the problems can be found in everyday life.

From the participants' worksheet, the researchers grouped into two groups, the group of participants who completed stages for solving the problems and the groups of participants who didn't complete stages for solving the problems.

TABLE 1. Framework for Mathematical Representation Translation Analysis

Step	Step of Ill-Structured Problem Solving	Activities of Representation Translation	Indicators	Codes
1.	Analyze and Browse (A and B)	unpacking the source	subjects read the ill-structured problem aloud or silently; subjects verbalize the ill-structured problem using the usual style of talk; or subjects used visual representation to explain the problem subjects used verbal, visual, or symbolic representations to collect information or data necessary to solve the given problem	VbAB-1; VsAB-1; or SbAB-1 VbAB-2; VsAB-2; or SbAB-2
2.	Create (C)	preliminary coordination	subjects used verbal, visual or symbolic representations to formulate solutions that can satisfy a multitude of conditions.	VbC-1; VsC-1; or SbC-1
3.	Decision-Making (D)	constructing the targets	subjects used verbal, visual, or symbolic representations to justify the most appropriate solution to the problem from a mathematical perspective subjects used verbal, visual, or symbolic representations to justify their argument to choose the final solution	VbD-1; VsD-1; or SbD-1 VbD-2; VsD-2; or SbD-2
4.	Evaluation (E)	determining equivalence	subjects used verbal, visual, or symbolic representations to evaluate other participants' sets of solutions to compare them to their problem-solving process and do they reflect on the differences	VbE-1; VsE-1; or SbE-1

As for participants who were stated to be able to solve the problem completely, they were participants who fulfilled the stages of ABCDE which included Analyze, Browsing, Create, Decision-Making, and Evaluation. Analyze is the stage when participants review the problem from an analytical perspective with verbal, visual, and symbolic representations, browse is the stage when they collect information or data necessary to solve the given problem, create is the step when they formulate solutions that can satisfy a multitude of conditions, decision-making is a stage when they justify the most appropriate solution to the problem from a mathematical perspective, and evaluation is the stage when they evaluate other participants' sets of solutions to compare them to their problem-solving process and do they reflect on the differences.

Only two participants completed the steps for solving the ill-structured problem. The researcher chooses the participants who completed the ill-structured problems to be research subjects called S1 and S2. Subjects are then interviewed for data. After the data was collected, then performed the analysis, then interpreted. The process of data analysis in this study contains the following steps: (1) transcoding the collected interview data, (2) understanding all existing data from various sources (interviews, photos, videos, field notes, student answers), (3) categorize and organize the collected data by making the coding, (4) describe the subject's mathematical representation, (5) analyze the subject's mathematical representation and their translation process-based framework in Table 1, (6) analyze the unique things (if any), and (7)) make a conclusion.

RESULT

After examining the participants' worksheet and think-aloud results, the researcher found that only 8.3% of participants were able to answer correctly about an ill-structured problem. From that fact, it showed that participants had difficulty in solving the problem of social arithmetics in ill-well structure problems.

Of the two selected subjects namely students who can complete ill-structured problems in full, then the results of the data analysis are as follows:

1. First Subject (S1)

S1 starts resolving ill-structured problems by representing problems visually, S1 describes the information that is known by describing rectangles to represent baking pans and drawing circles to represent cake containers. S1 writes the size of each picture. At the analysis stage, S1 states verbally when interviewed that there are many possible correct answers to the problem, this is because there is no known baking sheet height and cake container and unknown cake size. Then S1 represents verbally the procedure he uses to obtain a solution, namely by dividing the base of the cake container by the base area of each cake. The breadth of each cake is obtained by dividing the width of the baking sheet by many cakes. In the last stage, monitoring, S1 without re-checking verbally stated that the final answer obtained was 11 which was a rounding result of 11.05.

The results of the work and the statement stated by the S1 when thinking aloud when solving ill-structured problems through perception are as follows.

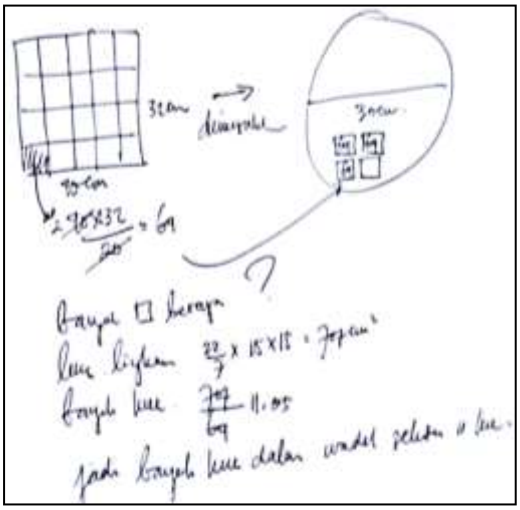

FIGURE 3. S1's Ill-Structured Problem Solving Worksheet

S1: *Because in the matter there is only a known baking pan and cake box, here I describe the square as a known size baking pan and circle like a cake box with a diameter of 30 cm. The baking pan is divided into 20 like this because it is known that there are 20 cakes. Then the goal is to move each part of my shading into a circle. Furthermore, because we didn't know the height of the baking pan and the height of the cake box, I consider the height of both cakes to be the same, so we can get the number of cakes by dividing the breadth of the cake box with the width of each cake. We the area of each cake here we can calculate by multiplying 40 and 32 then the results we divide by 20 so that we get 64 for each cake. So a lot of cakes is the area of a circle that is 705 divided by 64 results in 11.05 then rounded to 11. So there are lots of cakes in the cake box around 11 cakes.*

The results of the description of S1's mathematical representations in completing the above ill-structured problems are then analyzed based on the framework in Table 4.

2. Second Subject (S2)

S2 starts resolving ill-structured problems by representing problems visually, S2 describes the information that is known by describing rectangles to represent baking pans and drawing circles to represent the cake box. S2 writes the size of each picture. At the analysis stage, S2 states verbally when interviewed that there are many possible correct answers to the problem, this is because there is no known baking sheet height and cake container and unknown cake size. Then S2 assumed that the height of the baking pan, cakes, and cake box was equals. S2 represents verbally the procedure he uses to obtain a solution by compiled division. The breadth of each cake is obtained by dividing the width of the baking sheet by many cakes. In the last stage, monitoring, S2 without re-checking verbally stated that the final answer obtained was 11 cakes.

The results of the work and the statement stated by the S2 when thinking aloud when solving ill-structured problems through perception are as follows.

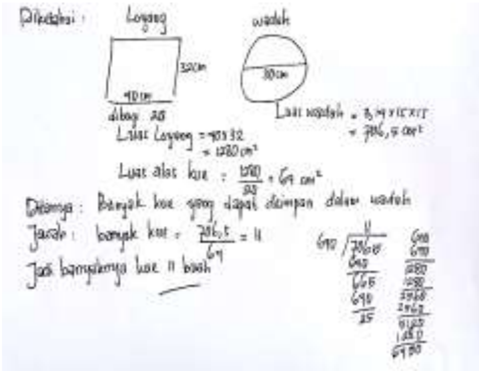

FIGURE 4. S2's Ill-Structured Problem-Solving Worksheet

S2: *From the problem, I will describe the rectangle of 40cm 32 cm as a baking pan and circle like a cake box with a diameter of 30 cm. The baking pan is divided into 20 like this because it is known that there are 20 cakes. Then the question is to move each part of my shading into a circle. Furthermore, I assumed the height of the baking pan and the height of the cake box, I consider the height of both cakes to be the same, so we can get the number of cakes by dividing the breadth of the cake box by the width of each cake. The area of each cake here we can calculate by multiplying 40 and 32 is 1280 and then the 1280 is divided by 20 so that we get 64 for each cake. So a lot of cakes is the area of a circle that is 706,5 divided by 64 results 11. So the final answer is 11 cakes.*

TABLE 4. Result of Mathematical Representation Analysis in Ill-Structured Problems Solving

Activities in Ill-Structured Problem Solving	Indicator of Mathematical Representation Analysis in Ill-Structured Problem Solving
S1 described the square as a known-size baking pan and circle like a cake box with a diameter of 30 cm.	VbAB-1 VsAB-1
S1 said that the baking pan is divided into 20 like this because it is known that there are 20 cakes	VbAB-2
S1 claimed that goal of problem is to move each part of cake into a circle	VbAB-2 VbC-1
S1 explain that S1 didn't know the height of the baking pan and the height of the cake box, I consider the height of both cakes to be the same, so we can get the number of cakes by dividing the breadth of the cake box with the width of each cake.	VbD-1 VbD-2 SbD-1 SbD-2
S1 is calculated by multiplying 40 and 32 then the results divide by 20 so that S1 gets 64 each cake. S1 explained that a lot of cakes is the area of a circle that is 705 divided by 64 results 11.05 then rounded to 11.	SbD-1 SbD-2
S1 justified the final solution that there are lots of cakes in the cake box around 11 cakes	VbE-1

The results of the description of S2's mathematical representations in completing the above ill- structured problems are then analyzed based on the framework in Table 5 and the following results are obtained:

TABLE 5. Result of Mathematical Representation Analysis in Ill-Structured Problems Solving

Activities in Ill-Structured Problem Solving	Indicator of Mathematical Representation Analysis in Ill-Structured Problem Solving
S2 described the rectangle 40cm ✕ 32 cm as a baking pan and circle like a cake box with a diameter of 30 cm	VbAB-1 VsAB-1
S2 said that the baking pan is divided into 20 like this because it is known that there are 20 cakes	VbAB-2 SbAB-2
S2 said that the question is to move each part of my shading into a circle	VsAB-2 VbC-1
S2 assumed that the height of the baking pan and the height of the cake box, I consider the height of both cakes to be the same	VbD-1 VbD-2 SbD-1 SbD-2
S2 explained the area of each cake here we can calculate by multiplying 40 and 32 is 1280 and then the 1280 divide by 20 so that we get 64 each cake	SbD-1 SbD-2
S2 justified the final solution is 11 cakes because S2 calculated by multiplying 40 and 32 and then the result divide by 20 so the answer is 64, and then the area of a circle that is 706,5 divided by 64 results 11	VbE-1

Based on Table 4 and Table 5, the S1 and S2 solution steps to solve an ill-structured problem can be described as follows:

1. S1 and S2 failed to solve ill-structured problems because their translation of mathematical representation didn't accurate.
2. S1 can't be unpacking the source when problem representation.
3. S2 can't verify the equivalence between source representation and target representation
4. S1 and S2 have inconsistent representation translation schematic when solving an ill-structured problem

The mathematical translation schema described in Figure 5.

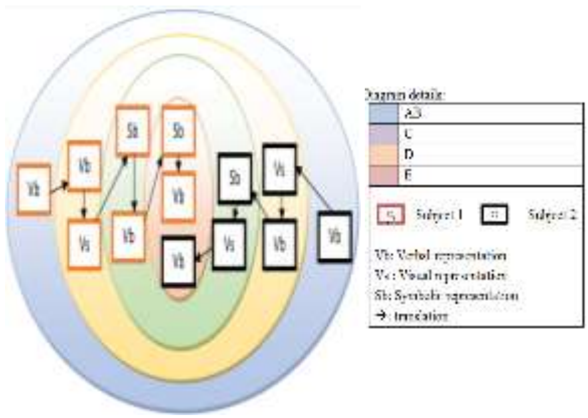

FIGURE 5. Stages of Subjects Mathematical Representation Translation Schema in Ill-Structured Problem Solving

DISCUSSION

The empirical data shows the mathematical representations created by the students when solving the ill-structured problem. They made their notations regarding concept understanding but often had difficulty in transitioning their symbolic representations. There was a lack of understanding of symbol notations, which could be seen in S2's confusion when monitoring and evaluating to develop the final solution, and in the fact that S1 rarely made verbal representations in writing but used the moral to describe the analysis and evaluation, he made in developing the final solution. Without using many types of representations and tending to use verbal representations, S1 was able to give an argument about the solutions selected.

Based on the theoretical framework and results, we found that the two subjects had different methods of using mathematical representations to solve an ill-structured problem. It showed that the success of problem-solvers is based on their ability to build problem representations in a problem-solving situation [16,17]. The process of selecting problem representations causes different characteristics when solving ill-structured problems, which are visual-verbal and verbal-verbal problem solvers. These characteristics show that there is a strong relationship between success in solving ill-structured problems and the translation of representation skills. The findings are by following Villegas et al., who state that there was a strong relationship between success in solving problems and skills in the construction, use, and articulation of representation [6].

Another finding from this research is that in addition to the diversity of representations, the accuracy of the translation process between types of representations also determines the success of problem-solving.

According to Vost & Post (2014) said that translation representation reduces the level of abstraction of a representation. This is in line with Bosse et al., (2014), Rahmawati et al., (2017), and Swastika et al., (2018) said that the accuracy in determining the representation of sources and targets, prior calling of knowledge, and the mapping process between source representation and target representation are important aspects in the translation process.

CONCLUSION

This research analyzed the process of mathematical representation and identified mathematical representations style by applying ill-well-structured-problem solving activities to problem-solving learning approaches for mathematics education students. The finding of the present research is that students' mathematical representation forms affect ill-well-structured-problem solving competencies. The schemas of mathematics education students' representations in solving ill-structured problems show that they do tend to use visual-verbal and verbal-verbal representations. Verbal and symbolic representations are used by mathematics education students to calculate, detect, correct errors, and justify their answers, but visual representations are used by mathematics education students to detect and correct errors.

Both subjects failed to solve ill-structured problems because their translation of mathematical representation didn't accurate. They can't be unpacking the source when problem representation and determining equivalence between source representation and target representation. From the founded, the researcher concluded that ill-structure problem must often be given to students to practice their translation representation capabilities

Furthermore, the studies will be carried out by increasing the number of subjects and extending the study period so that the pattern of translation of mathematical representations in solving ill-structured problems is obtained.

Declaration by Authors

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