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Analysis of University Students' Mathematical Representation in Solving Geometry Problems

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***Abstract*—This research is qualitative research with a descriptive, explorative approach. That aim is to describe the ability of students' mathematical representation in solving geometry problems. The population was all Mathematics Education Study Program who programmed the Basic Geometry Course. The sampling techniques were Stratified Sampling and Purposive Sampling. The instruments were an initial test to categorize the students' problem-solving skill into three categories (high, medium, and low), a diagnostic test to get the external representation data, and interview guidelines to obtain the internal representation data. The instruments were valid and reliable. This study also conducted triangulation techniques to test the validity of the data. The results show that: Firstly, the high-ability students in solving geometry problem tended to present the visual representation appropriately, to write mathematical expressions inappropriate symbols, and to employ verbal representation at each stage in solving the problem. Secondly, the middle-ability students presented visual representations but less representative, used mathematical expressions but lack verbal representations. Finally, low-ability students in solving the geometry problem did not present appropriate visual representations, use little mathematical expression and limited verbal representations.**

Keywords—mathematical representation, problem-solving, geometry

I. INTRODUCTION

A good geometry problem-solving process cannot be separated from the ability to represent the problem mathematically. In line with that, the National Council Teaching of Mathematics (NCTM) in Principles and Standards for School Mathematics in 2000 [1] wrote representation as the fifth standard process, after problem-solving, reasoning, communication, and connection. The underlying reasons according to Jones [2] are: (1) fluency in translating the different forms of representation is a fundamental ability that students need to have to develop concepts and mathematical thinking, (2) the way teachers present mathematical ideas through various representations have a huge influence on students' understanding in learning mathematics, and (3) students need practices in developing their own representations so that they have a strong and flexible ability and understanding in solving problems. The problem-solving from George Polya mentions four steps to make students in solving mathematical problems systematically, 1) understanding problems, 2) planning, 3) carrying out the plan, and 4) checking all the answers.

Based on the preliminary observations in Basic Geometry class at Mathematics Education Study Program, the University of West Sulawesi, it was discovered that there were several obstacles experienced by students. One of the obstacles faced is that students tend to experience difficulties in solving problems. This course presents problems that require students to think critically and systematically to prove the theorems and the use of these theorems in solving geometry problems.

The difficulties encountered were caused by the students were not being able to associate mathematical concepts, especially geometry, with other concepts. When a student was given a theorem to prove it, the student looked confused and didn't know how to start, and what to do. There were students who did not understand the intent of the theorem. There were also some students who knew the intention of the theorem but still did not know how to write the proof, and how to represent systematically and mathematically. Furthermore, the lack of mathematical representation affects the inability to solve problems. It is because if students do not know how to represent a problem into a mathematical model, they will have difficulties in solving the problem [3]. As a result, students are not able to solve any problem. Another problem observed is that the students worked less systematically and pay less attention to the solution steps. Students only gave priority to the end result. Many important steps were not written in solving the problem.

It needs to describe deeply on how the students perform their mathematical representation ability in solving geometry problems. The subjects were students in Mathematics Education study programs as prospective teachers who will later teach geometry to students in school. This study is a preliminary study to describe the ability of students. It is expected that this study can provide information in order to find solutions to problems related to students' mathematical representation abilities and problem-solving skill.

II. LITERATURE REVIEW

The term mathematics representation is not new in the education field, especially in mathematics learning. Representation has become important and worth. According to Hudojo [4] representation becomes important as a means of communication and thinking. Furthermore, representation makes mathematics more concrete in order to make it easier to reflect. In addition, students are helped in developing

their reasoning skill since they can organize their thinking to develop varied approaches in solving problems.

There are several reasons why representation ability is needed. According to Jones [5], the representation is important since it develops fluency in a concept and mathematical thinking; the ideas are given by the teacher greatly influence students' understanding of mathematics; it develops the strong and flexible understanding of a concept. The ability to present mathematical ideas with a high structure can be carried out with an inductive-deductive approach.

Based on that explanation, mathematical representation ability can be interpreted as an ability of students in configuring mental images or their thinking from the learning process through mental development that is visualized in verbal forms, pictures, notations, or concrete objects that symbolize mathematical ideas or situations in certain ways.

Hwang et al. [6] state that representation, based on context, consisted of external representations (real word) and internal representations (mind). Internal representations, of course, cannot be observed by naked eye and consequently, cannot be assessed, someone minds are difficult to know. However, the manifestation of the minds will be seen in words (verbal) or writings in the form of statements, symbols, expressions, mathematical notations, pictures, or graphics. It is called an external representation. The internal representation is defined as the process of thinking about mathematical ideas that allow one's mind to work on the idea [7]. Understanding the mathematical concepts is not storing past experiences, but how to get back the knowledge that has been stored in memory and relevant can be used when they are needed. The process of obtaining relevant knowledge is closely related to coding past experience. This process is a mental activity, which is therefore called an internal representation [8].

In solving mathematical problems, especially geometry, mathematical representation is needed which are useful tools for understanding geometry concepts. And using the representations to complete tasks and to explain to others [9]. Students construct their geometrical concepts from multiple representations such as drawing concrete from abstract ideas through mental or physical manipulation [10].

III. Research Methods

A. Types of Research

This is qualitative research with the descriptive-exploratory method. This study describes the actual situations of students at Mathematics Education Study Program regarding their ability in mathematical representations in solving geometry problems.

B. Research Procedure

The procedure describes a follow: (1) designing and validating instruments; (2) deciding research subjects based on (a) pre-test (b) GPA, and (c) Observation in Geometry class; 3) Gathering data from pre-test, diagnostic test, interview, and triangulation; (4)Analyzing the data qualitatively and quantitatively; (5) Writing down the implementation (discuss the analysis result based on the indicators) based on mathematics representation in solving geometry problem, and (6) Writing the research report.

C. Location and Subject Research

This study was conducted in the Mathematics Education Study Program, Faculty of Teaching and Education. Universitas Sulawesi Barat. The subjects were students at Mathematics Education Study Problem, Semester II, the academic year 2018 who enrolled in Basic Geometry Course class.

D. Research Variable

The variable in this study is students' ability of mathematical representation in solving geometry problems. The subjects were asked to solve a diagnostic test in order to get the students ability of mathematical representation data. Additional data gathered from the interview. Description of students' mathematical representation refers to the indicators of mathematical representations by Mudzakir [11]. The indicators are visual representations in the form.

E. Instrument and Data Collection Technique

The main instrument in this study is "the researcher" as data collectors through observation and in-depth interviews. In addition, supporting instruments in this study were: 1) pretest, some problems have been studied in Geometry class. The test results are used as a reference to decide the research subjects. The subjects were selected based on the categories (Table 1), 2) a diagnostic test for describing mathematics representation ability in solving geometry problems are in written tests (essay). The data from the test were analyzed based on mathematical representation indicators from Polya's problem-solving stages of knowing for the ability level of the students' mathematical representation in each stage. This test is included in the external representation. This data is strengthened by the results of observations and interviews, and 3) interview guideline instrument, the questions are based on the purpose of the study. It expected to understand the students 'mathematical representation in solving geometry problems related to abstraction based on Polya's steps and to explore information on students' thinking processes in the answer sheet of a diagnostic test.

TABLE I. Geometry Problem Solving Ability Categories

Scoring Initial Test Score	Assessment Category
0 – 49	Low
50 – 75	Medium
76 – 100	High

The three instruments were validated by an expert. Observation, interviews, and written tests are used as methods to gather the data. The methods were used as a triangulation by the method. The aim is to get valid and reliable data. The result from interviews compared to the data obtained from the analysis of the results of diagnostic tests and interviews with the students verbally and visual, mathematical representation ability in solving geometry problems.

F. Data Analysis Technique

The interview transcripts and diagnostic test results were analyzed with the following steps: 1) Analyzing all available data from various sources: the results of diagnostic tests, interviews, and observations written in the field notes; 2) Reducing the data. Diagnostic test data and transcripts of interviews that are not in accordance with the research objectives were omitted; 3) Presenting the data covers the classification and identification data; 4) Coding which aims to make the data easier to present; 5) Checking the validity of data on the students' mathematical representation ability in solving geometry problem; 6) Describing data; and 7) Drawing conclusions and verification.

IV. RESULT

A. Pretest Result on Description of Students'Initial Ability in Solving Geometry Problem

Frequency distribution score for pretest for initial ability in solving geometry problems from 54 students of Mathematics Education Study Program as in table 2.

TABLE II. FREQUENCY DISTRIBUTION SCORE OF PRETEST ON PROBLEM SOLVING SKILL

Score	Frequency	Percentage (%)	Category
0-49	10	18.52	Low
50-75	35	64.81	Middle
76-100	9	16.67	High
Total	**54**	**100%**	

Table 2 shows that of the 54 students who took the pretest of geometry problem-solving skills, 9 students (16.67%) categorized as high problem-solving abilities, 35 students (64.81%) had middle problem-solving abilities, and 10 students (18.52%) show low problem-solving abilities. This result shows that the geometry problem-solving ability of students at Mathematics Education Study Program is generally in the middle ability category.

B. The description of Mathematics Representation Ability

To methods were used to gather the data on students' mathematics representation ability; diagnostic test and interview. The data analyze through triangulation method from the results of the diagnostic test and interview from identical subjects who have identical mathematical representation. The analysis was going on until the data convergent and valid to represent each category of problem-solving skill in the pretest; high, middle, and low. The description of each subject describes later.

C. Mathematical Representation Ability of High Category Subjects

The description of mathematical representation ability in solving geometry problems shows that the high-ability subjects have a tendency to use various mathematical representations at each stage of problem-solving. As in problem I, at the stage of understanding the problem and planning the problem-solving strategy, the subjects used visual representations in the form of geometry images, symbols, and uses verbal representations. In addition, at the problem-solving stage, the subjects employed geometry / mathematical expressions and text / words. And at the re-checking stage, the subject uses visual representations in the form of geometry images and mathematical expressions.

In problem II, the stage of understanding the problem and planning a problem-solving strategy, the subjects showed multiple representations which were also in the form of geometry images, symbols, and using verbal representations. Meanwhile, at the problem-solving stage, the subjects used geometry / mathematical expressions and text / words. And at the re-checking stage, the subject used only mathematical expressions. Similarly, in problem III, the subjects also used multiple representations in understanding the problem and planning problem-solving strategies. They made geometry patterns, symbols, and using text representations. Meanwhile, at the problem-solving stage, the subject employed geometry / mathematical expressions and text / words. And at the re-checking stage, the subjects used only mathematical expressions.

D. Mathematical Representation Ability of Middle Category Subjects

The description of mathematical representation ability in solving geometry problems shows that the middle-ability subjects tend to use various mathematical representations in problem-solving, but less representative of each stage of problem-solving. As in problem I, at the stage of understanding the problem, the subjects only used mathematical expressions, and at the stage of planning a problem-solving strategy, the subjects performed visual representations as geometric images, geometric symbols, and verbal representations. At the problem-solving stage, the subjects employed geometry / mathematical expressions and text / words. And at the re-checking stage, the subjects did not write anything on the diagnostic test. However, they were able to explain the way during the interview.

In problem II, in the stage of understanding the problem, the subjects performed mathematical and text expressions, and in the stage of planning a problem-solving strategy, the subjects used multiple representations as well in the form of geometric drawings, geometric symbols, and using verbal representations. Meanwhile, at the problem-solving stage, the subjects used geometry / mathematical expressions and text / words. And at the re-checking stage, the subject did not write anything on the diagnostic test, but the verbally was able to explain the way during the interview.

In Problem III, they also used multiple representations at the stage of understanding the problem and planning the problem-solving strategy; the subjects used only text representation. Next, at the problem-solving stage, the subjects performed geometry patterns, geometry symbols / mathematical expressions and text / words. And at the re-checking stage, again the subject did not write anything on the diagnostic test, but verbally was able to explain the way during the interview.

E. Mathematical Representation Ability of Low Category Subjects

The description of students' mathematical representation ability in solving geometry problems shows that the low-ability subjects lack the ability to use various mathematical representations in problem-solving. In the problem I, at the stage of understanding the problem, the subjects used visual

representations in the form of geometric images, geometric symbols, and uses verbal representations. The stage of planning a problem-solving strategy, the subject only used text. Although the strategic plan had been written down, the subjects were unable to solve the problem. Furthermore, in problem II, the stage of understanding the problem, the subjects performed multiple representations also in the form of geometric images, geometry symbols, and using verbal representations. The stage of planning a problem-solving strategy, the subjects only used the text. In the problem-solving stage, the subjects were unable to solve the problem. Furthermore, in Problem III, in the stage of understanding the problem and planning a problem-solving strategy, the subjects only used a text representation. Furthermore, in the stage of problem-solving, the subjects performed less representative geometrical patterns. They were unable to solve the problem properly. Thus, the subjects in the low ability category were unable to complete all three problems in the diagnostic test.

V. CONCLUSION

The conclusions of this study are: 1) Students ability in solving geometry problem are in the high category 16.67%, the medium category 64.81%, and the low category 18.52%, 2) the mathematics representation ability of high-ability subjects in solving every geometry problems always presents an appropriate visual representation, mathematical reform expressions inappropriate symbols, and using verbal representation at each stage of problem-solving; the middle-ability subjects present visual representation but less representative, using mathematical expressions and verbal representations; and low-ability subjects did not present the right visual representation, use a little mathematical expression and tend only to use verbal representations and cannot answer all problems.

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