The identification of the difficulties in solving mathematical problems of junior high school mathematics teachers in Nusa Tenggara Timur and Maluku Utara

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***Abstract**: This study aims to determine the difficulties in solving mathematical problems of junior high school mathematics teachers in Nusa Tenggara Timur and Maluku Utara, two of the 33 provinces in Indonesia. The method used in this study was descriptive exploratory. The data analysis was based on 114 junior high schools mathematics teachers' responses to the five items of the National Examination questions. The items were the most difficult items according to the students, particularly those of the junior high schools in Nusa Tenggara Timur and Maluku Utara, whose graduation has not reached 100%. The result of the analysis indicated that the order of teachers' difficulties in solving mathematical problems is executing the problem solving plan, understanding the problems, interpreting the results and designing the problem solving plan. Based on this study, 46.491% teachers had difficulty in executing the problem solving plan, 45.846% in understanding the problem, 43.129% in interpreting the results and 33.063% in designing the problem solving plan.*

***Keywords**: difficulties, mathematical problems, problem solving*

1. Introduction

Various factors influence the success of education (Bridge, Judge & Mock, 1979). Based on the review of these various factors, the teacher factor has 15% contribution to the student success (Sallis, 2002). In order to be a teacher who has a great role in determining the success of the students, teachers should ideally have personal competence, social competence, academic competence, and professional competence. Supporting the success related to the academic professional competence, teachers must be able to master learning materials. That is the major component in professional competence. These competencies can be determined by evaluating the teacher, by administering a test, and by analyzing the test.

The results of the study conducted by Mardapi, Soenarto, and Retnawati, (2011) show that the ability of the teachers who teach at junior high schools, whose National Examination score is low, is also low in mastering learning materials. In this study, teachers' ability data in mastering learning materials in 100 districts/cities in Indonesia was necessary. The data source was teachers' responses to the essay test for the subjects tested in the National Examination at junior

high schools, senior high schools and vocational schools. The overall information obtained from all over Indonesia was grouped into four regions, covering Java (Region 1), Sumatra (Region 2), Sulawesi, Kalimantan, Nusa Tenggara Barat (Region 3), and Nusa Tenggara Timur, Maluku Utara, Papua (Region 4).

However, the teachers' responses to the essay tests have not been fully exploited and explored. One thing that can be done in order to maximize the utilization of the data was to identify the teachers' difficulties in solving mathematical problems. Problem solving in mathematics includes several things, namely conceptunderstanding,languageinterpretation, algorithms, and computation. The mistake made by the teachers which causes their lack of ability to solve the mathematical problem can be explored using their responses to the essay test. The results of the data exploration can be presented as a problem solving error profile performed by mathematics teachers. Based on that profile, there are various improvement efforts that can be planned, namely policy, training, community service, and other actions that can improve teachers' mastery of the subject matter. Those improvement efforts are also useful to improve teachers' abilities in solving problems in order to improve their' academic professional quality. Based on this background, this study revealed the junior high school teachers' difficulties in solving mathematical problem according to Polya. Teacher's ability to solve mathematical problems is the reflection of their ability in mastering the learning material. Mastering the learning material is very important in the learning activities.

An educational evaluation is conducted to obtain information related to education. According to Gronlund (1976), educational evaluation has many purposes, namely a) to provide clarification of the learning outcomes that have been implemented, b) to provide information about the achievement of short-term goals, c) to provide feedback for the learning progress, d) to provide information about the difficulties in learning activities and the selection of learning experience for the future. The information generated by an evaluation activity can be used to determine: a) the suitability and sustainability of the learning goals, b) the usability of learning materials, and c) the level of efficiency and effectiveness from the teaching strategies used in the classroom (methods and learning techniques).

One interesting problem related to the evaluation and its results is problem related to mathematics. There are various opinions expressed by experts about the definition of Smathematical terms. According to Gold (2008), mathematics has many interpretations. Mathematics can be defined based on its contents (Gold, 2008), based on the objects studied by mathematics learners (Avigad, 2008), and it can also be defined as a process of thinking (Lewis). Reys, et al. (1998) define mathematics as a lesson about the patterns and relationships, ways of thinking, art characterized by rules and consistency, language that uses terms and certain symbols, as well as a useful tool in everyday life and also tools that assist the development of other existing knowledge.

Mathematics is also known as a structure of relationships that associates symbols. This opinion is based on the idea about the formation of mathematics. Related to that statement, Ruseffendi in Ismail (1998) argues that mathematics is formed as a result of human thinking associated with the ideas, processes and reasoning. Related to the process of formation, mathematics is also known as a knowledge which belongs to human being. This knowledge arises because of the need of human being to comprehend the nature around

them. Nature is the source of idea to obtain mathematical concepts through abstraction and idealization.

After the model is created, definitions and axioms are created based on that model. Definition is an agreement used to replace something else, usually an expression or replacement to replace something that is too difficult to write (James & James, 1976). An axiom is a statement that is accepted without proof. A theorem is obtained through the process of thinking called deductive logic (Allendoerfer, 1969). The theorem resulted from the thinking activity is a general conclusion that can be proven (James & James, 1976). The definition, axioms and theorems are a unitary system that constructs a mathematical concept.

Mathematical objects are abstract. They correlate with each other and form a new more complex concept (Skem, 1971). They are arranged in a hierarchy, so one concept is the basis for another concept (Herman Hudoyo, 1988:3). Mathematical concepts that are founded are applied to the nature. People use them to fulfill their needs in their life.

Mathematics is knowledge which is very useful in human life. This knowledge is used to resolve problems (Polya, 1973). There are four stages in solving a problem according to Polya, namely understanding the problem, designing the problem solving plan, executing the problem solving plan, and interpreting the results. These stages are presented in Table 1.

The variable associated with the success in mathematics learning is the teacher's competence. According to the Republic of Indonesia Government Regulation No. 19 Year 2005, Article 28, Section 3 and Law No.14 Year 2005, Article 10, Section 1 "The competence of educator as a teaching agent in primary and secondary education as well as in early childhood education includes (a) pedagogical competence, (b) personal competence, (c) professional competence and (d) social competence. The teachers' professional competence according to Law No. 14 Year 2005 is mastering the materials, structures,

Table 1.
Stages in Solving a Problem Designed by Polya

Stages in Problem Solving	Ideal Criteria
Understanding the problem	1. Able to write down the core problem 2. Write down the obtained data 3. Able to model the problem question and select the appropriate notation 4. Make a sketch related to the problem solving if necessary
Designing the problem solving plan	1. Find the pattern used for solving the problem 2. Know the formula related to the problem solving 3. Know the prerequisite conditions for solving the problem
Executing the problem solving plan	Perform calculation based on the designed plan
Interpreting the results	1. Check the steps that have been done 2. Interpret the results as a conclusion 3. Look back and find out if the core of the problem has been aswered in the conclusion.

concepts, and scientific mindset that support the teaching subjects, mastering the standard and basic competencies of the teaching subjects, developing the learning materials creatively, developing the teacher's professionalism by doing a reflective action sustainably, utilizing information and communication technology in order to develop their professionalism.

Polya (1984) created "Ten Commandments For Teachers" containing ten things that should be noted by teachers to improve their professional competency. These 10 principles are: 1) Be interested in your subject line; 2) Know your subject; 3) Try to read the faces of your students; try to see the reviews of their expectations and difficulties; put yourself in the reviews of their place; 4) Realize that the best way to learn anything is to discover it by yourself; 5) Give your students not only information, but also know-how, mental attitudes, the habits of methodological work; 6) Let them learn to guess; 7) Let them learn to prove; 8) Look out for the reviews of such features of the problem at hand as may be useful in solving the problems to come - try to disclose the general pattern that lies behind the present concrete situation; 9) Do not give away your whole secret at once - let the students guess before you tell it - let them find out by themselves as much as is feasible; 10) Suggest it; do not force it down to review their throats.

2. Method

This study used the descriptive exploratory method with the quantitative approach. The teachers' difficulties in solving matematical problems are identified based on the stages in the problem solving according Polya. The object used in this research was the responses of the junior high school teachers to the National Examination questions. Mathematics teachers who participated in this study consist of 111 junior high school mathematics teachers in Nusa Tenggara Timur and three junior high school mathematics teachers in Maluku Utara. They teach at the junior high schools which graduated less than 80% of the students in 2010 and 2011. The National Examination questions (multiple-choice type) are modified to an essay test. The rubric from this essay test was designed based on Polya's problem solving stages, including understanding the problem, designing the problem solving plan, executing the problem solving plan, and interpreting the results.

The data used in this study were collected using the documentation method. The data were obtained through research activities of Puspendik Balitbang Kemendikbud (Education Research Center, Research and Development Bureau, Ministry of Education and Culture) in 2011. The data were in the form of the teachers' responses to the National Examination questions (essay test for the 9th and 12th mathematics teachers who teach at junior high schools and senior high schools, especially in science and social science department). The data have not been analyzed, especially in relation to the steps of the utilization of mathematics as a tool to resolve problems. A test was used to determine the teachers' mastery of the teaching material according to the SK/KD (standard and basic competencies). The test was compiled based on the material considered difficult by students, based on students' absorptive capacity in the last five or six years (2006-2011). The National Examination mathematics score for each school was obtained from Puspendik Balitbang Kemendiknas.

The data were analyzed quantitatively. The quantitative descriptive analysis was used to identify the profile of the difficulties faced by the mathematics teachers at junior high schools in Nusa Tenggara Timor and Maluku Utara, whose graduation is less than 80%. The

Table 2.
Distribution of Research Sample Junior High School Mathematics Teachers Who Participated in Competency Tests Administered by Balitbang (Research and Development Bureau)

Regional	Province	Frequency
	DIY	39
	Jakarta	18
Region I	Banten	17
	Jawa Tengah (Central Java)	45
	Jawa Timur (East Java)	31
Number of Teachers in Region I		150
	Aceh	33
	Bangka Belitung	45
Region II	Sumatra Barat (West Sumatra)	115
	Kepulauan Riau (Riau Islands)	10
	Lampung	8
Number of Teachers in Region II		211
	Kalimantan Barat (West Kalimantan)	65
	Kalimantan Tengah (Central Kalimantan)	28
	Kalimantan Timur (East Kalimantan)	57
	Nusa Tenggara Barat	23
	Gorontalo	4
	Sulawesi Barat (West Sulawesi)	9
	Sulawesi Selatan (South Sulawesi)	51
	Sulawesi Tenggara (Southeast Sulawesi)	10
Number of Teachers in Region III		247
	Nusa Tenggara Timur	111
	Maluku Utara (North Maluku)	3
Number of Teachers in Region IV		114
	Total	722

teachers' difficulties included the difficulties in understanding concepts, language interpretation, algorithms, and computational capabilities. The achievement of the teachers was correlated with the average of the school score in mathematics. The recommended suggestion based on the results of this analysis was the suggestion that can be used to improve the education quality, especially to increase the teachers' ability in solving mathematical problems related to their professional abilities.

Table 3.
Graduate Competency Standards that were Difficult to Achieve and Used as Test Instruments by Balitbang

Number	Competency Standards Used as a Problem
1	Determining the surface area of the curved side
2	Determining gradients, equations, and graphics
3	Solving problems with the concept of congruency
4	Determining the volume of the curved side
5	Determining the central tendency and its use to solve daily problems

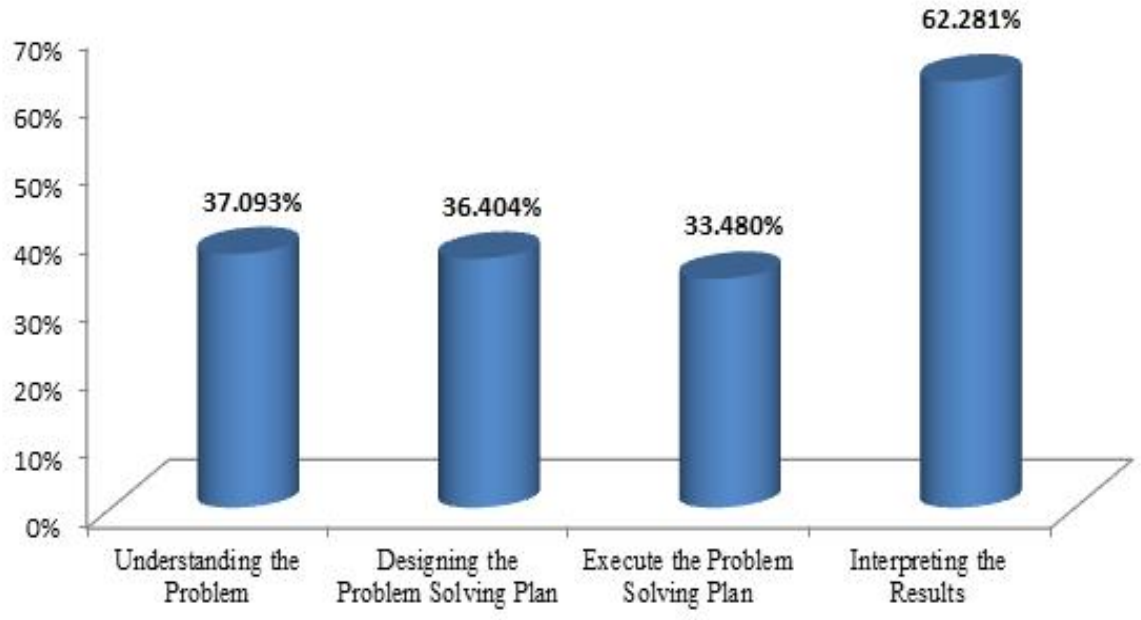
3. Findings and Discussion

Determining the Surface Area of a Cone

As many as 37.093% teachers from the total of 114 mathematics teachers in Region 4 did not understand the problem of the 1st question well. Understanding the problem of the 1st question was divided into four steps or substages based on Polya's Problem Solving Model, namely write down the core of the problem, write down the obtained data, model the question and select the appropriate notation and also make a sketch related to the problem solving. The teachers' difficulties in answering the 1st question measured by mistakes that they made are presented in Figure 1.

Mathematics teachers in Region 4 could understand the core of the mathematical

Figure 1: Teachers' Difficulties in Solving the Problem of the 1st Question



problem presented in the 1st question. It was known from the percentage of the teachers who made mistakes on the first stage, understanding the problem: write down the core problem. There were just 42.982% teachers who made a mistake at the first stage. As many as 29.240% teachers in Indonesia did not write down the obtained data. At the sketching stage, 85.088% mathematics teachers could not use a sketch as a tool for solving the problem. In the next stage, designing the problem solving plan, there were 23.684% teachers who made mistakes. They had difficulty in finding and using the formula to calculate the surface area of a cone. The detailed percentages of the mistakes made by the teachers at each substage of Polya's Problem Solving model are presented in Table 4.

Determining Gradients, Equations, and Graphics

The 2nd question is related to the straight line function that was perpendicular to the other line and through a point. There was an additional problem. The teachers also must draw two lines in a Cartesian field. The teachers' difficulties in answering the 2nd question are presented in Figure 2.

Mathematics teachers in the Region of Nusa Tenggara Timur and Maluku Utara did not understand the problem well. As many as 38.158% teachers did not understand the core of the problem and they were not be able to write down the obtained data. In designing the problem solving plan stage, there were 70.833% teachers that did it well. The most important thing in solving problem of the 2nd question based on Polya's model was the interpreting of the result stage. The detailed percentages of teachers' mistakes in solving the 2nd question are presented in Table 5.

Solving Problems with the Concept of Congruency

The 3rd question related to geometry is focused on congruency. This question was combined with the triangles and the Pythagorean Theorem. The percentages of the teachers' difficulties in answering the 3rd question are presented in Figure 3.

The teachers' difficulties on the 3rd question were relatively high when compared to the teachers' difficulties on the 1st and 2nd questions.

Table 4.
Summary of the Teachers' Difficulty in Solving the Problem of the Test Item Number 1

Polya's Stage	Polya's Substage	Percentage
Understand the problems	Write down the core of the problem	42.982%
	Write down the obtained data	29.240%
	Model the question and select the appropriate notation	21.930%
	Make a sketch related to the problem solving	85.088%
Designing the problem solving plan	Know the prerequisite conditions for solving the problem	23.684%
	Find the pattern used for solving the problem or know the formula related to the problem solving	49.123%
Implementation Of the Problem Solving Plan	Find the prerequisite conditions for solving problem	24.123%
	Find a final solution	52.193%
Interpret the results		62.281%

Figure 2: Teachers' Difficulties in Solving the Problem of the 2nd Question

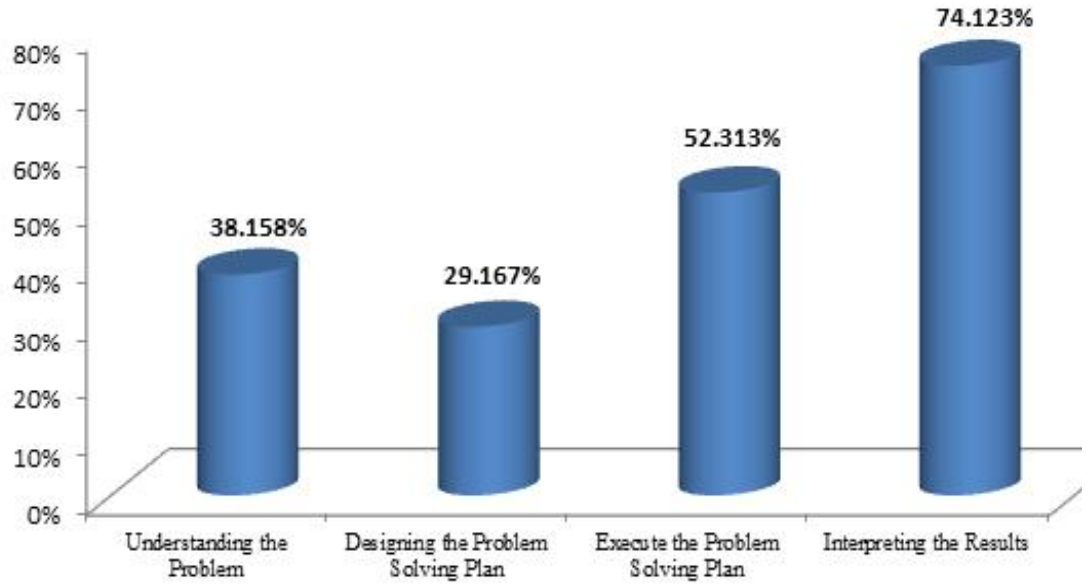
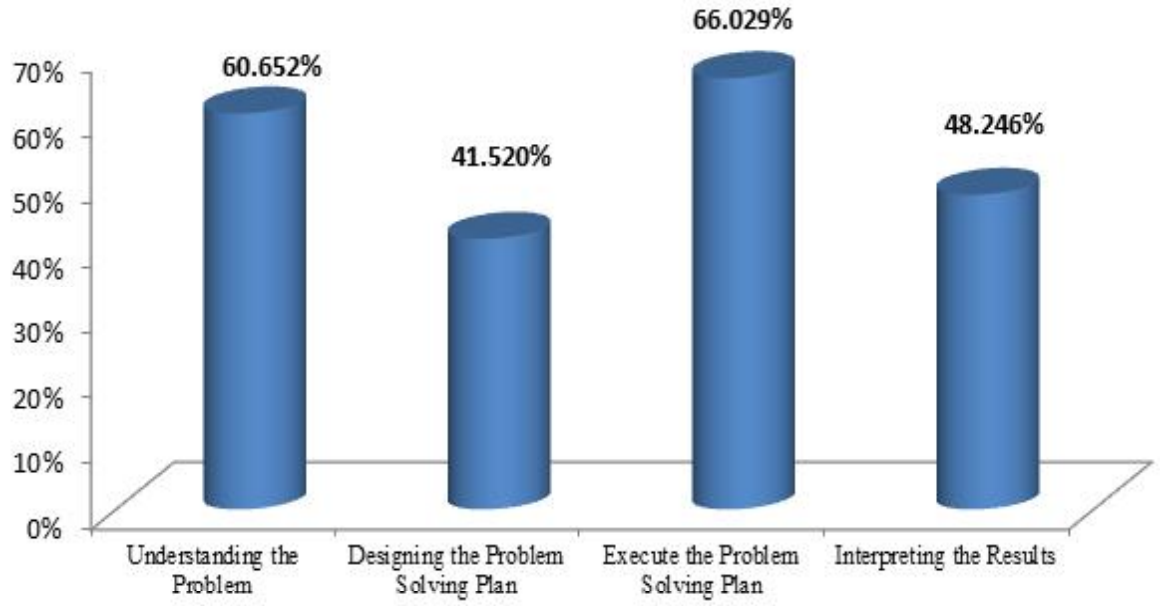


Table 5.
Summary of the Teachers' Difficulty in Solving the Problem of the Item Test Number 2

Polya's Stage	Polya's Substage	Percentage
Understand the problems	Write down the core of the problem	35.965%
	Write down the obtained data	40.351%
	Model the question and select the appropriate notation	28.509%
	Make a sketch related to the problem solving	29.825%
Designing the problem solving plan	Know the prerequisite conditions for solving the problem	32.456%
	Find the pattern used for solving the problem or know the formula related to the problem solving	56.725%
Implementation Of the Problem Solving Plan	Find the prerequisite conditions for solving problem	74.123%
	Find a final solution	35.965%
Interpret the results		40.351%

This can be seen from the percentage of the mistakes made by the teachers. The teachers had difficulties in understanding the problem, designing the problem solving plan, executing the problem solving plan, and interpreting the results. Most of the teachers had difficulties

Figure 3: Teachers Difficulties in Solving the Problem of the 3rd Question



in understanding the problem and designing the problem solving plan. The percentages of the teachers' difficulties at those stages were higher than those at the two other stages.

As many as 72.807% teachers did not draw a sketch to help in solving a problem. There are 54.386% of the teachers who had the idea to use the concept of congruence or Pythagorean Theorem in solving the problem in the 3rd question. Most of the mathematics teachers in Region 4 only assumed without proven the existence of a pair of congruent triangles. After they assumed that there were two congruent triangles, 40.643% of them made a mistake in the calculation. The detailed percentage of teachers' mistakes in solving the 3rd question is presented in Table 6.

Determining the Volume of The Curved Side

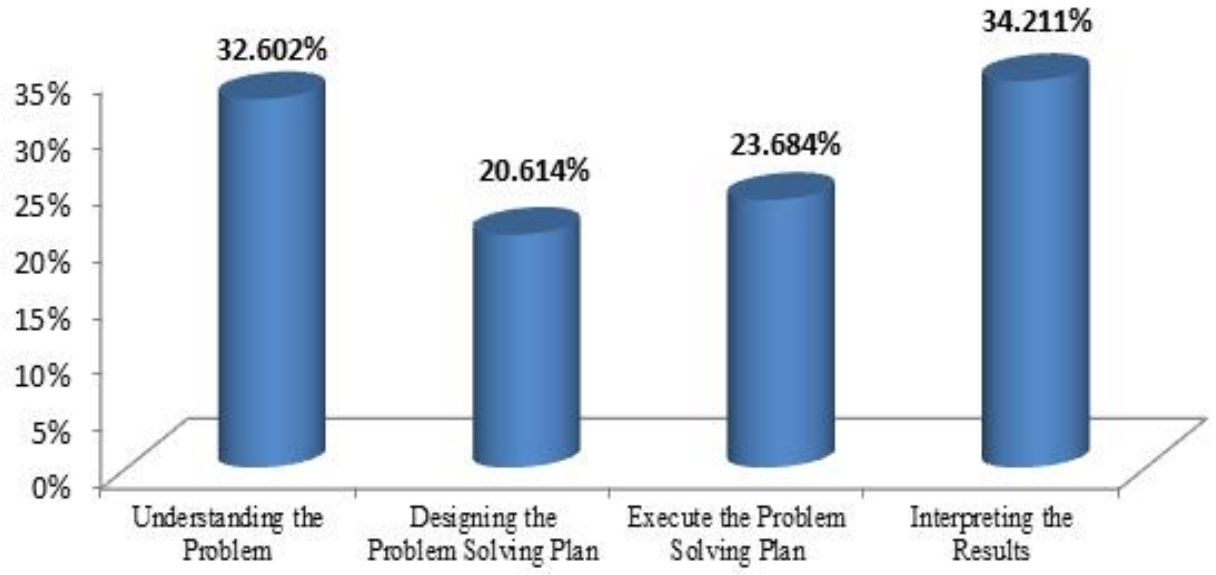
The teachers' difficulties in solving the problem of the 4th question about the volume of the cone with unknown length radius are presented in Figure 4.

As many as 32.602% teachers in Nusa Tenggara Timur dan Maluku Utara had difficulties in understanding the problem of the 4th question. Most teachers understand the core problem but only 23.684% made sketch related to the problem in order to find the radius length of a cone. Based on the percentages of the teachers' difficulties in Figure 4, mathematics teachers in Region 4 did not have difficulties in answering the 4th question. There were common mistakes made by the teachers, namely the teachers did not write the conclusion and they did not provide the unit so they did not answer the questions correctly. The detailed percentages of mistakes made by the teachers at each substage of Polya's in solving the 4th question are presented in Table 7.

Table 6.
Summary of the Teachers' Difficulty in Solving the Problem of the Test Item Number 3

Polya's Stage	Polya's Substage	Percentage
Understand the problems	Write down the core of the problem	28.947%
	Write down the obtained data	64.561%
	Model the question and select the appropriate notation	72.807%
	Make a sketch related to the problem solving	45.614%
Designing the problem solving plan	Know the prerequisite conditions for solving the problem	39.474%
	Find the pattern used for solving the problem or know the formula related to the problem solving	96.491%
Implementation Of the Problem Solving Plan	Find the prerequisite conditions for solving problem	40.643%
	Find a final solution	48.246%
Interpret the results		28.947%

Figure 4: The Percentages of Teachers' Difficulties of the 4th Question



Determining The Central Tendency and Using It to Solve Daily Problems

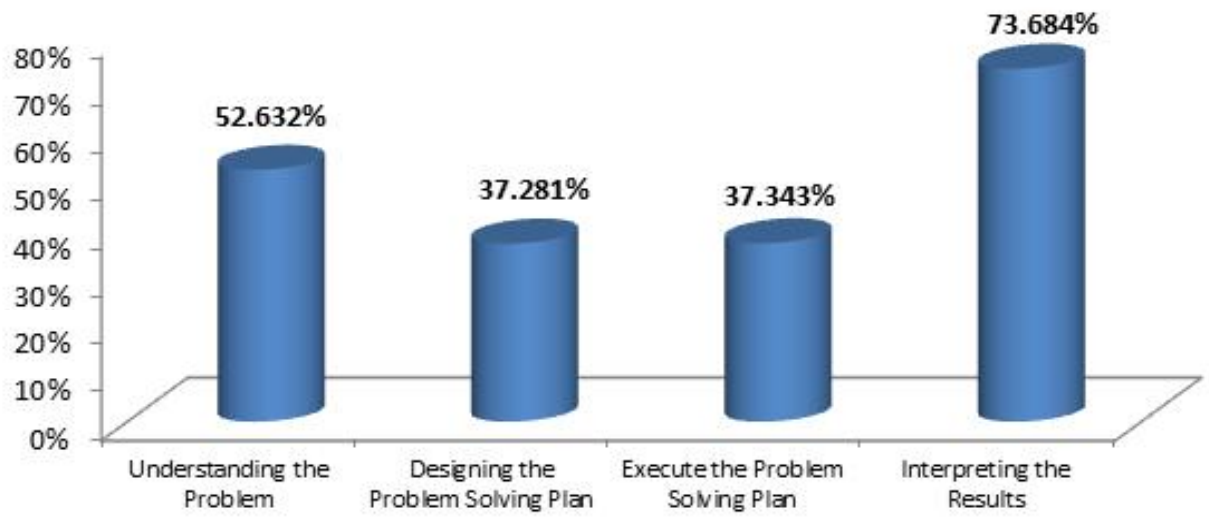
The problem of the 5th question was about the statistical problems. The teachers were asked to calculate the average based on two different averages. The percentages of the teachers' difficulties in answering the 5th question are presented in Figure 5.

The percentage of the teachers' difficulties in understanding the problem is 52.632%.

Table 7. Summary of the Teachers' Difficulty in Solving the Problem of the Test Item Number 4

Polya's Stage	Polya's Substage	Percentage
Understand the problems	Write down the core of the problem	16.667%
	Write down the obtained data	23.684%
	Model the question and select the appropriate notation	23.684%
	Make a sketch related to the problem solving	84.211%
Designing the problem solving plan	Know the prerequisite conditions for solving the problem	21.930%
	Find the pattern used for solving the problem or know the formula related to the problem solving	19.298%
Implementation Of the Problem Solving Plan	Find the prerequisite conditions for solving problem	21.491%
	Find a final solution	28.070%
Interpret the results		34.211%

Figure 5: Teachers' Difficulties in Solving the Problem of the 5th Question



This indicates that there were mistakes made by the teachers. Most of the teachers know the core of the problem but they did not write down the obtained data and they also did not model the question and select the appropriate notation. There are 37.343% teachers who had difficulties in designing the problem solving plan and 37.343% teachers had difficulties in executing the problem solving plan. The detailed percentage of the mistakes made by the teachers at each substage of Polya's in solving the 5th question are presented in Table 8.

Table 8. Summary of the Teachers' Difficulties in Solving the Problem of the Test Item Number 5

Polya's Stage	Polya's Substage	Percentage
Understand the problems	Write down the core of the problem	31.579%
	Write down the obtained data	53.509%
	Model the question and select the appropriate notation	56.140%
	Make a sketch related to the problem solving	39.474%
Designing the problem solving plan	Know the prerequisite conditions for solving the problem	35.088%
	Find the pattern used for solving the problem or know the formula related to the problem solving	34.430%
Implementation Of the Problem Solving Plan	Find the prerequisite conditions for solving problem	41.228%
	Find a final solution	73.684%
Interpret the results		34.211%

4. Conclusion

The results of this study indicate that the order of difficulties from mathematics teachers of junior high schools in Region 3 in solving mathematical problems are in executing the problem solving plan, understanding the problems, interpreting the results, and designing the problem solving plan. Based on this study, 46.491% teachers have difficulties in executing the problem solving plan, 45.846% in understanding the problem, 43.129% in interpreting results and 33 063% in designing the problem solving plan.

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