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MATHEMATICAL PROBLEM SOLVING ABILITY BY USING THE POLYA MODEL AT ELEMENTARY SCHOOLS

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Abstract

The rapid development of science and technology demands education to produce human resources that have high-order thinking skills including mathematical problem-solving abilities. Indonesia's PISA ranking in 2018 is fallen down compared to the 2015 PISA results. For the mathematics category, Indonesia is ranked 7th from the bottom (73) with an average score of 379. In Indonesia, around 71% of students do not reach the minimum competency level of mathematics. It means that there are still many Indonesian students who have difficulty dealing with situations that require the ability to solve problems by using mathematics. Based on these data, it appears that many students have not met the minimum competencies at school. This research approach is descriptive-qualitative which aims to see the students' ability to solve math problems in elementary school. The instruments in this study were tests and interviews. The results of this study show that students are categorized into three levels of ability, they are high, medium and low. The students categorized into high level mathematical problem solving abilities are 36% of the total students, medium are 40% and low are 24%. From the results of the interviews it was also obtained that the students' difficulties in solving problems were 1) Students had difficulty in understanding the keywords that appeared, thus they could not interpret them in mathematical sentences. 2) Students cannot determine what to do and what information from the problem is needed to solve it, 3) Students do not understand the problem, they tend to guess the answer, 4) Students are impatient and don't like reading math problems, and 5) Students do not like to read long questions.

Keywords: Mathematical Problem Solving Ability, The Polya Model

INTRODUCTION

The rapid development of science and technology demands educational system to produces human resources that have high-order thinking skills. Higher-order thinking skills such as critical thinking, discussion, decision-making and scientific thinking are needed to help individuals solve their problems (Yılmaz-özcan & Tabak, 2019). Problem solving is a central point of mathematics education, therefore, every student is required to have problem solving skills (Barham, 2020). This is also reinforced by National Council of Teachers of Mathematics (2012) which states that problem solving skills are one of the main purpose in learning mathematics. Besides that, learning mathematics aims to help the students solve problems in their everyday life. Next is to help students build thinking processes that lead to further abilities to solve non-mathematical problems.

Problem-solving is a compulsory skill for students to face a changing and challenging future. Students who have good problem-solving skills will be better prepared to cope with change and adapt quickly. Students who have good resolution skills are students who develop critical thinking skills, such as analysis, evaluation, and selection of relevant information. This will help them in making good decisions. The ability to solve

problems encourages creativity because it involves the ability to think creatively, find unconventional solutions, and see problems from different perspectives. It helps students become more innovative in responding to challenges. Career preparation is also a goal of students being equipped with good problem-solving skills as many modern jobs require problem- solving skills. Students who have these skills will be more desirable by prospective employers and have better career prospects. In addition, problem-solving is an attempt to increase mental endurance because it can help students cope with stress and stress well. Students will be better able to cope with problems and avoid despair.

Problem solving skills are generally defined as a person's ability to engage in cognitive processes to understand and solve the problems in situations where methods for solving problems are not immediately available (Shute et al., 2016). Based on research conducted by Van Galen & Van Eerde (2013), students do not understand the process of solving problems and do not know how to solve problems because the teacher has never given non-routine questions. According to Kamaliyah et al. (2013), problem solving skills must be taught from elementary school because students tend to form their own mindset when they are in elementary school. Problem solving skills will also train students' observation and exploration skills because in order to be able to solve problems students need the ability to analyze more deeply about a topic (Mohammad Archi Maulyda , Vivi Rachmatul Hidayati & Nurmawanti, 2019).

For elementary school students, the most mistakes in math tests are doing word problems that require problem solving ability. It is generally caused by reading skills, comprehension, transformation, or carelessness. Students often do one or more of the four calculation operations (+, −,×, ÷) needed to answer questions, but they don't know which operations to use to solve the problem (Clements et al., 2004). Fractions material is no exception. Fractions are introduced for the first time to elementary school students and then deepen them at the next level of education. Fractions are subject matter that has many implications in everyday life and is even a prerequisite material and is widely used in other subject matter. Based on the research results of Ramlah, Bennu, Sudarman, Paloloang (2019), student errors in solving fraction problems lay on the incomplete procedures of problem solving. In this study, Polya's steps will be used to analyze student errors in solving fraction problems. Polya steps are used because in the steps there is a systematic procedural which will help students in solving problems. The aim of this study is to see which step that the students have difficulty solving the problem provided. The novelty in this study lies in the analysis of students' errors in solving mathematical problem in Fractions material by using Polya Steps.

In solving problems, it is not only about using formulas but also about using reasoning, analysis, critical thinking to get a solution to solve the problem (Fahrudin et al., 2019). This is become the basis for Polya to develop steps to solve the problem. The first step is to understand the problem. The second step is to create a problem solving plan. The third step is Carrying out the Plan and the fifth is evaluating (Polya, 1978).

Mathematics has a very big role in developing human thinking in the process of developing strategic and systematic reasoning in analyzing to solve problems. This role assists the students in planning, deciding and solving their own problems in everyday life. In addition, mathematics is also a tool to study about technology and other sciences (Phonapichat et al., 2014).

Indonesia's PISA ranking in 2018 is fallen down compared to the 2015 PISA results. For the mathematics category, Indonesia is ranked 7th from the bottom (73) with an average score of 379 (Tohir, 2019). In Indonesia, about 71% of students do not reach the minimum competency level in mathematics. This means that there are still many Indonesian students who have difficulty dealing with situations that require problem-solving skills using mathematics (OECD, 2019). Based on these data, it appears that many students have not met the minimum competencies at school.

This is also reinforced by the results of field study conducted by Indahwati et al. (2020), students are able to do the carrying out the plan stages but students have not been able to carry out the process of understanding the problem. In addition, Ulandari et al. (2019), Surya et al. (2017) and Yerizon et al. (2018) states that the ability to solve mathematical problems in Indonesia is still relatively low. Some of these studies are the basis of this research. In the problem solving process there are several steps that need to be done. According to Polya there are 4 stages that must be carried out to see students' problem solving abilities. In this study an analysis will be carried out to find which stage the students often miss or are unable to do it. Previous research has discussed problem solving using the polya model, but has not analyzed the steps to find out where students are in solving problems about fractions where there are many errors. This aims to ensure that mistakes made can be resolved in teaching fractions for the next time. The goal is that teachers can emphasize these errors more in providing material to students. Lack of understanding of the concept of fractions, decimals and percent will influence on students in develop reasoning knowledge proportional and algebra topics as well as probability (Behr et al., 1985).

The fragment material is vital for students to understand because it allows us to model complex situations and perform accurate calculations. By learning fractions, students can understand the deeper mathematical concepts. The fractions are the basis for many more complex mathematics concepts, such as comparisons, ratios, proportions, percentages, decimals, and decimal fractions. Financial calculations like in financial and business matters, fractions are used to calculate profits, losses, discounts, taxes, and percentages. Fractions are also used in financing, such as loans, mortgages, and investments. In terms of living skills, the ability to understand and use fragments is an essential skill in everyday life. It can help in financial planning, shopping, cooking, or construction, where fragments are often used.

METHODS

The approach used in this research is descriptive-qualitative. According to Creswell (2012), a qualitative approach is a research procedure that produces qualitative data, words or notes from the people themselves or the behavior they observe. This type of research was chosen because the purpose of this study was to see the students' ability to solve math problems in elementary schools. This research was located at SDN 06 Kp. Lapai, Jhoni Anwar Street No.45, Kp. Lapai, Nanggalo, Padang City, West Sumatra.

The school was chosen because it has been accredited A which already represents schools in general in the city of Padang. In addition, SDN 06 KP. Lapai is also the best school that often participates in supporting the activities of the Padang City Education Office. Students at SDN 06 Kp. Lapai also has various abilities, namely low, medium and high. For the research procedure, students are given post-test questions and short

interviews. In accordance with the criteria in this study, 3 high-ability students, 3 low-ability students and low-ability students will be selected to confirm the answers. Polya (1978) Suggests four steps of problem solving namely understanding the problem, Devising a Plan, Carrying out the Plan, and Looking Back. Score rubric can be seen in table 1.

Table 1: Scoring Rubric of Problem Solving Questions

Score	Understanding the Problem	Devising a Plan	Carrying out the Plan	Looking Back
0	Misinterpreted or completely wrong	No plans or making plans that are irrelevant	Not doing calculations	There is no inspection or other information
1	Misinterpreted some of the questions and ignored the conditions of the questions	Create a solution plan that cannot be implemented, so it cannot be implemented	Executes the correct procedure and may produce the correct answer but miscalculates	There is an examination but it is not complete
2	Understand the problem completely	Making plans that are right but wrong in results or no results	Do the right process and get the right result	Checks are carried out to see the correctness of the process
4		Make a correct plan but not complete		
5		Make plans according to procedures and lead to the right solution		
Score	2	4	2	2

Source by Amam (2017)

The test results and student interviews were analyzed by using Polya's Steps according to Table 1. Students' problem-solving abilities were analyzed based on these steps which would give results whether the indicators matched or not.

RESULTS AND DISCUSSION

The results of this study were obtained from the test results in the form of word problem questions. The material provided is about fractions. From the results given, the following results are obtained:

Table 2: The Assessment of Students' Problem Solving Ability

Level MPSS	The number of students	Percentage	Rating Category
0 ≤ Scor < 65	6	24	Low
65 ≤ Scor < 80	10	40	Medium
80 ≤ Scor ≤ 100	9	36	High

Explanation: MPSS = Mathematical Problem Solving Score

Based on Table 2 above, it can be seen that the percentage of students' mathematical problem solving abilities with high level abilities is lower than those with medium abilities and low abilities. The ability of more students are in the medium category.

Student answer sheets were analyzed based on Polya's stages. Quantitatively, the percentage level of students' mathematical problem solving abilities based on Polya stages can be seen in Table 3.

Table 3: Students' Problem Solving Ability Based on Polya Stages

Problem Solving Stages	The number of students	Percentage
Understanding the Problem	25	100
Devising a Plan	24	96
Carrying out the Plan	20	80
Looking Back	9	36

Based on Table 3 above, it can be seen the percentage of fifth grade students in solving mathematical problem solving questions based on the Polya stages. The sequence of percentages of students' mathematical problem solving stages from highest to lowest is the stage of understanding the problem, followed by the stage of Devising a Plan, the stage of Carrying out the Plan and finally the stage of Looking Back.

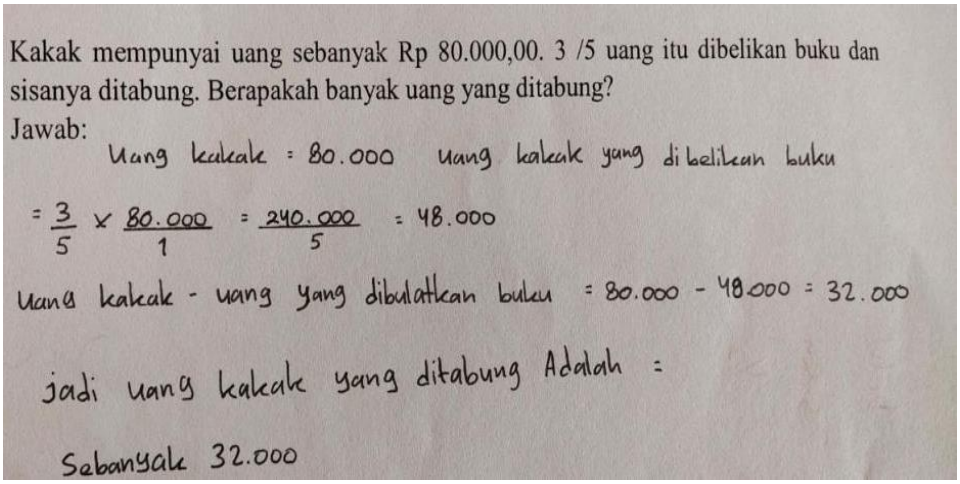
Quantitatively, the classification of the mathematical problem-solving abilities of high-ability students based on the Polya stages can be seen in Table 4.

Table 4: Classification of Problem Solving Ability from the Test Results for High-ability Students

Problem Solving Stages	The number of students		
	Correct answer	Wrong answer	No answer
Understanding the Problem	9	-	
Devising a Plan	8	-	-
Carrying out the Plan	9	-	-
Looking Back	6	-	1

Based on Table 4 above, it can be seen the classification of mathematical problem solving abilities based on the Polya stage of high-ability students. Where at the Looking Back stage there was 1 student who did not do it.

From the analysis carried out, the students who have high abilities in answering the question number 1 are more likely to answer the questions like the following picture:


Kakak mempunyai uang sebanyak Rp 80.000,00. 3 /5 uang itu dibelikan buku dan sisanya ditabung. Berapakah banyak uang yang ditabung?
Jawab:
Uang kakak = 80.000 uang kakak yang dibelikan buku
$= \frac{3}{5} \times \frac{80.000}{1} = \frac{240.000}{5} = 48.000$
Uang kakak - uang yang dibulatkan buku = 80.000 - 48.000 = 32.000
jadi uang kakak yang ditabung Adalah =
Sebanyak 32.000

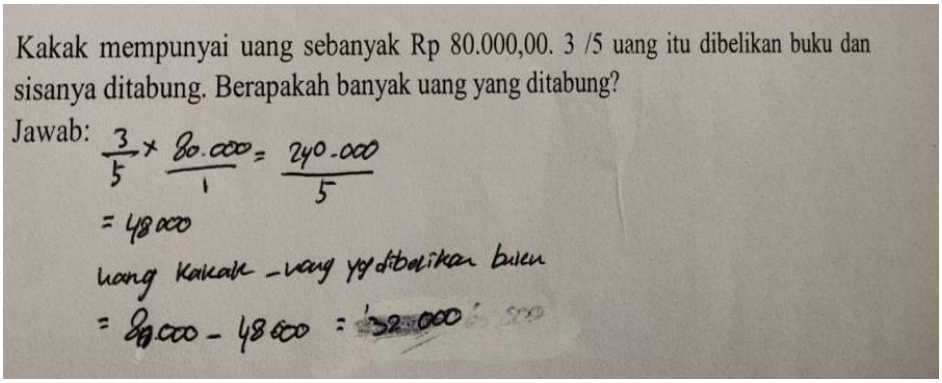
Picture 1: Answers of high ability students

Quantitatively, the classification of the mathematical problem solving abilities of medium abilities students based on Polya stages can be seen in Table 5.

Table 5. Classification of Problem Solving Ability from Test Results for Medium Ability Students

Problem Solving Stages	The number of students		
	Correct answer	Wrong answer	Correct answer
Understanding the Problem	10	-	
Devising a Plan	10	8	-
Carrying out the Plan	9	1	8
Looking Back	3	-	5

Based on Table 5 above, it can be seen the classification of mathematical problem solving abilities based on the Polya stage of medium abilities students. Where at the Looking Back stage there were 3 students who did not do it. The following are the answers of students who have the medium ability.



Picture 2: Answers of medium ability students

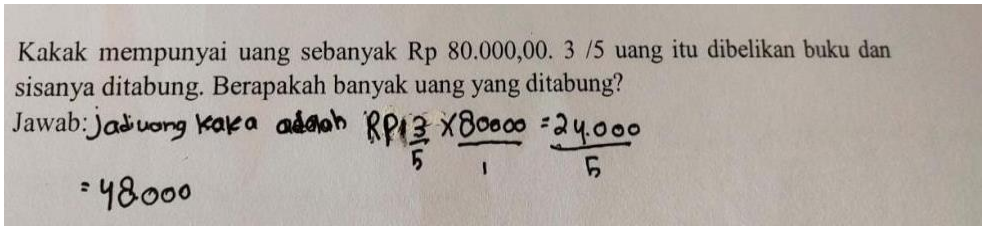
Quantitatively, the classification of the mathematical problem solving abilities of low abilities students based on Polya stages can be seen in Table 6.

Table 6: Classification of Problem Solving Ability from Test Results for Low Ability Students

Problem Solving Stages	The number of students		
	Correct answer	Wrong answer	Correct answer
Understanding the Problem	6	-	
Devising a Plan	6	-	-
Carrying out the Plan	2	4	-
Looking Back	-	-	6

Based on Table 6 above, it can be seen the classification of mathematical problem solving abilities based on the Polya stage of students with low abilities. Where at the Looking Back stage there were 6 students who did not do it.

The way of students who have low abilities in answering the question number 1 can be seen in the following picture:



Picture 3: Answer of low ability students

Schoenfeld (2016) placing mathematical problem solving in the hierarchy of skills to be acquired by students leads to certain consequences for the role of mathematical problem solving in the curriculum. Students can be said to have the ability to solve problems (Polya, 1978) if in solving the problem in questions through these 4 stages, namely: (1) Understanding the problem; (2) Devising a Plan; (3) Carrying out the Plan; and (4) Looking Back. In this study, 3 items were used to reveal student performance in solving students' mathematical problems where each item included stages of solving mathematical problems.

Based on the results of the study, it was obtained an overview of students' mathematical problem solving abilities based on the Polya stages: Students with high abilities are able to understand the problem. This is characterized by (1) being able to write down what is known and asked in the problem, (2) being able to explain the problem using their own sentences, (3) being able to simplify the problem, and (4) being able to find sub-objectives and being able to sort the information in the problem. At the Devising a Plan stage, the students are able to (1) understand the relationship between what is known and what is asked, (2) make plans or strategies for solving problems, and (3) determine the mathematical operations used to solve problems. At the Carrying out the Plan stage, they are able to carry out the completion plan that has been made with the correct calculations.

At the Looking Back stage, the students are able to interpret the final results obtained from previous answers into the context of the problem and provide arguments. This is in accordance with the results of the study conducted by Saparwadi & Cahyowatin (2018) which stated that high-ability students were able to understand the problem by understanding the vocabulary of the questions, identifying all the facts in the form of information data contained in the test questions, connecting all the information from the identification results, and ending with identifying questions from the problem solving test instrument as the desired goal achieved. The Students are able to compile a solution plan with the selection of operations based on the identification results of all information data in the problem. Furthermore, they are able to carry out plans and be able to re-examine the results obtained by substituting the results obtained into the initial equation. The suitability of the substitution results into the initial equation shows that the results obtained by students are correct and the goals have been achieved based on the solutions to the problems faced by students.

Students with medium ability at the stage of understanding the problem are able to (1) write down what is known and asked in the problem, (2) explain the problem using their own sentences during interviews, (3) find the sub-objectives, and (4) sort the information in the problem. At the Devising a Plan stage, they are able to understand the relationship between what is known and what is asked, then they can make plans or strategies to solve problems. At the Carrying out the Plan stage, they are able to carry out the completion plan that has been made with the correct calculations. At the Looking Back stage they have not been able to interpret the final results obtained into the context of the problem and provide arguments. The students are only able to make conclusions from the solution he made.

This is in accordance with the results of the study conducted by Rianti et al. (2018) which states that students with medium abilities are able to understand the problem by writing down what is known and asked in the problem, less able to make a solution plan; writing a formula that can be used to solve the problem even though it is not

complete. Students are less able to carry out plans and very less in checking back results.

Students with low abilities at the stage of understanding the problem are able to write down what is known and asked in the questions, but are unable to explain the problem back in their own sentences as well as that was proven during the interview. At the Devising a Plan stage, they understand the relationship between what is known and what is asked, but cannot make plans or strategies for solving problems, and are unable to sort the information in the problem. At the stage Carrying out the Plan, they are not able to make the completion stage. At the Looking Back stage, they are unable to interpret the final results obtained into the context of the problem and provide arguments. To check back the answer, they did not do it. During the interview, he students were only able to draw conclusions without being linked back to the problem.

Based on the research conducted, the percentage of students' abilities for the stage of understanding the problem was 100%, the stage of Devising a Plan was 96%, the stage of Carrying out the Plan was 80%, and the stage of Looking Back was 36%. The results of these studies are relevant to research conducted by NoprianiLubis et al. (2017) that shows the percentage of students' ability to understand the problem reaches 87.10% and is in the very good category, the percentage of students' problem solving abilities to plan is 40.32% in the unfavorable category, the percentage of students' ability to solve problems according to the plan is 21.19% classified in very less, the percentage of students' ability to re-examine the results obtained was 48.39% in the unfavorable category.

Based on the results of the research and opinions above, it can be concluded that students with high abilities are able to carry out the stages of problem solving properly and accurately, while students with medium abilities are able to understand problems, make plans and carry out plans well. Low ability students are able to understand the problem but are less able to make plans, carry out the plans, and do Looking Back.

Based on the research findings, interviews, and data triangulation, it was found that several student errors were found in solving word problem questions on Fractions material in accordance with problem solving steps. The majority of mistakes made by students were at the looking back stage, there are 16 students answered incorrectly and 12 students did not answer. This stage clearly shows students' inability to interpret the results obtained and provide their arguments.

Teaching and learning is a complementary activity, which is formally carried out in the school context. Teaching describes the actions of a teacher who helps the students to acquire and maintain knowledge, attitudes and skills (Eshun & Mensah, 2013). According to Wrenn & Wrenn (2009) Professional educators not only teach theory and why theory is important, but it is also important to apply the theory in practice.

Problem solving involves people effort to find solutions to the problems by using analytical thinking, critical thinking, creativity, reasoning, and experience with available information (Chi, Michelene T. H.; Glaser, 1985). The knowledge structure contains understandings, models, beliefs, and influences how we relate our shared experiences and how we solve problems that we encounter in everyday life at school, in activities, even in play (Resnick, Laurel B.; Glaser, 1975, Chi, Michelene T. H.; Glaser, 1985). This is in accordance with Polya (1973), students are said to be able to solve problems if in solving problem-solving questions they carry out 4 stages, namely: (1) understanding the problem; (2) Devising a Plan; (3) Carrying out the Plan; and (4)

Looking Back. So that the mistakes made by students in solving mathematical problem were analyzed based on the Polya mathematical problem solving stage. Errors in the context of teaching and learning mean errors in the perception of subjects/reproducing learning memory, someone makes mistakes as a result of wrong perceptions.

Based on the results of the study, it was obtained an overview of student errors in solving mathematical problem, they are: errors of high-ability students are at Looking Back stage, there was 1 student who did not do the looking back. It was concluded that the mistakes of high-ability students in solving mathematical problem solving were only at the Looking Back stage.

The errors of students with medium abilities are at the stage of devising a plans, 8 students were wrong in devising plans. The error was devising a problem-solving plan that could not be implemented, so that the plan could not be implemented. At the stage of Carrying out the Plan, there were 8 students who unable to carry out the settlement plan correctly, namely making a calculation error. At the Looking Back stage, there were 5 students who did not carry out the re-examining. It was concluded that the mistakes of medium ability students in solving mathematical problem were at the stages of devising plans, carrying out plans and looking back.

The errors of low-ability students are at doing the calculations, 4 students made errors in doing the calculations and 2 more students did not do the calculations. The error was at making a problem-solving plan that could not be implemented, so that the plan could not be carried out. At the Looking Back stage, all students with low abilities did not do it. It was concluded that the errors of low-ability students in solving mathematical problem solving were at the stage of devising the the plan and looking back.

For the analysis of student errors in solving fraction problems, the summary results of student interviews can be illustrated as follows:

Teacher *: Can you understand the problem in the questions?*

Student *: yes ma'am.*

Teacher *: then in which part do you have difficulty in answering the questions?*

Student *: The next step after knowing the problem asked.*

Teacher *: for calculating fractions do you know which arithmetic operations to use?*

Student *: difficult ma'am.*

Teacher *: after you finish the calculation, do you always make conclusions or look back at what was asked in the problem?*

Student *: sometimes ma'am*

The stage of understanding the problem is the stage where you have to be able to understand the language or terms used in the problem, formulate what is known, what is being asked, is the information obtained sufficient, what conditions/conditions must be met, write down the problem in a more operational form so that easier to solve (Simatupang et al., 2020). Correspondingly, Hung et al. (2016) states that in understanding the problem, one must understand the meaning of a sentence, identify what is known, what is not known and the relationship between information, and know the previously learned concepts needed to solve the problem. Student errors in solving mathematical problem at the stage of understanding the problem are 0%, meaning

that there are no student errors at this stage. Students are able to write down what is known and what is asked from the questions, but do not understand the meaning of a sentence. This is evidenced by the inability of students to reiterate what is known and what is asked without looking at the text so that theys do not understand the relationship between information. The inability to link information results in students not knowing the mathematical concepts that will be used to solve problems. The stage of Devising a Plan is the stage where looking for the possibilities that can occur and then compiling the settlement procedure. Ersoy & Güner (2015) argues the use of appropriate problem strategies is very important in the success of problem solving. Student errors in solving mathematical problem questions at the stage of understanding the problem are 57.9%.

At the stage of Devising a Plan, students cannot determine what to do to solve the problem so they make a mathematical operation error in compiling the steps for solving it. The students do not understand the problem correctly so they cannot develop a solution plan. Students' dislike of reading long and non-routine problems is also one of the reasons students make errors in devising plans. These results strengthen the findings of Cruz & Lapinid (2014) which revealed that carelessness, lack of understanding, changes in values, and foreign words were some of the common difficulties faced by respondents in translating word problems.

The stage of Carrying out the Plan is implementing the strategy that has been made with diligence and thoroughness to get a settlement. Student errors at the stage of making a settlement plan were 4%, while for the stage of carrying out the plan 20% and the stage of Looking Back what was done was interpreting the results obtained into the context of the problem was 64%. The errors made by students were the inability of students to interpret the results obtained in the context of the problem and provide their arguments. The students are used to making conclusions and are not doing the looking back stage.

The research above is relevant to research of Phonapichat et al. (2014). They concluded that students have difficulties in understanding mathematical problems that affect the problem solving process. Students' difficulties in solving problems are 1) Students have difficulty understanding the keywords that appear, thus they cannot interpret them in mathematical sentences. 2) Students cannot determine what to do and what information from the problem is needed to solve it, 3) Students do not understand the problem, they tend to guess the answer, 4) Students are impatient and don't like reading math problems, and 5) Students do not like to read long questions.

CONCLUSION

The results of this study show that students are categorized into three levels of ability, they are high, medium and low. The students categorized into high level mathematical problem solving abilities are 36% of the total students, medium are 40% and low are 24%. From the results of the interviews it was also obtained that the students' difficulties in solving problems were 1) Students had difficulty understanding the keywords that appeared, thus they could not interpret them in mathematical sentences. 2) Students cannot determine what to do and what information from the problem is needed to solve it, 3) Students do not understand the problem, they tend to guess the answer, 4) Students are impatient and don't like reading math problems, and 5) Students do not like to read long questions.

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