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ANALYSIS OF MATHEMATICS PROBLEM SOLVING ABILITY BASED ON POLYA PROBLEM SOLVING STEPS

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ABSTRACT

This research is a descriptive study with a qualitative approach that aims to describe the ability of students' mathematical problem-solving classes. The instruments in this study were a logical-mathematical intelligence test, a problem-solving ability test, and an interview guide. Data collection in this study was carried out using test, interview, and observation techniques. Checking the validity of the data carried out in this study was a technical triangulation. The results of this study indicate students' ability to solve mathematical problems based on Polya's problem-solving steps: (1) Understanding the problem, subjects who are able to correctly determine what is known and asked about the problem are subjects with high and moderate logical-mathematical intelligence, whereas subjects with low logical-mathematical intelligence are only able to determine things that are known in the problem and have not been able to determine what is being asked in the problem; (2) Develop a problem-solving plan, subjects who are able to develop relevant problem-solving plans to solve problems appropriately and find relationships between things that are known to find things needed in solving problems are subjects with high logical-mathematical intelligence, then for subjects with moderate logical-mathematical intelligence are only able to find connections between things that are known, whereas subjects with low logical-mathematical intelligence are not yet able to devise relevant problem-solving plans and find relationships between things that are known; (3) Carry out the plan, subjects who are able to carry out the steps of the problem solving plan correctly, are skilled in performing arithmetic operations, and find the right solution to the problem are subjects with high logical-mathematical intelligence, while subjects with moderate logical-mathematical intelligence and low ability to carry out a solution plan that is made even though it is not relevant to solving problems and less skilled in performing arithmetic operations, so that the right solution to the problem cannot be found; and (4) Re-checking, subjects who are able to interpret the solutions to the problems that have been obtained and re-examine the steps and calculation results are subjects with high, medium, and low logical-mathematical intelligence.

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1. INTRODUCTION

Mathematics is one of the basic sciences that has an important role in the world of education (Rokhataliyeva, 2022). Mathematics is given to students to help them organize their reasoning, form their personalities, and be skilled at using mathematics and their reasoning in later life. One of the characteristics of mathematics is that it has an object of abstract study. The basic objects of mathematics consist of facts, concepts, operations, and principles (Kaiser, 2020; Utaminingsih, 2022). These basic objects then develop into other objects. Therefore, learning mathematics must be done gradually, systematically, and based on past learning experiences (Xin et al., 2022).

Problem-solving ability is one of the mathematical abilities that students must have (Tambychik & Meerah, 2010; Tanjung et al., 2020). The National Council of Teachers of Mathematics (NCTM) stipulates five standards of mathematical ability that must be possessed by students, namely problem-solving abilities, connection skills, communication skills, reasoning abilities, and representational abilities (Hasibuan & Fauzi, 2019; Hasbi et al., 2019). Problem-solving is the process of finding or finding a way that bridges the situation being faced with the desired state. Or a process of looking for or finding a way to solve a problem that is being faced. Some of the opinions of experts in Aslan et al. (2021); Rahayuningsih et al. (2021); Jaelani et al. (2023) who support the importance of problem-solving for students include stating that (1) problem-solving abilities as one of the results of learning mathematics must be owned by students so that students are expected to become individuals who are able to solve the problems they face, (2) problem-solving skills as a component of the process involving students in understanding mathematics, and (3) problem-solving skills and knowledge will later be used and applied in real life in dealing with problems anything (Szabo et al., 2020).

One of the ideas regarding problem-solving was put forward by Polya. Polya suggests four steps of problem-solving in mathematics (Hensberry & Jacobbe, 2012; Brijlall, 2015; Dayo et al., 2020), namely: (1) understanding the problem; (2) devising a plan; (3) carrying out the plan; and (4) re-examination of the process and answers (looking back). By using these steps, it can be seen to what extent students' mathematical problem-solving abilities are developed.

The ability to analyze information used to solve problems is related to several other abilities, including identifying information, explaining interrelationships between patterns, and manipulating objects. Students must be able to find links between existing information on the problem so that an overview of problem-solving can be known. These abilities can be performed well by people who have good logical-mathematical intelligence. Logical-mathematical intelligence is those who work with abstract symbols and can see connections between pieces of information that others might miss (Azinar & Munzir, 2020; Prastika et al., 2021). Thus, problem-solving ability has a close relationship with logical-mathematical intelligence.

Based on the results of interviews conducted by researchers with Mathematics Teachers in Acceleration Classes at public middle school 6 Sengkang, information was obtained that the level of problem-solving abilities of students in these classes still varied. Not all students are able understand how to understand a problem and then determine a problem-solving plan until the right answer is found. If the teacher gives questions that are 'slightly' different from the questions that are usually given, students tend to have difficulty understanding the questions, which has an impact on the steps to solving the questions that students choose and take.

In research conducted by Masrurotullaily et al. (2013), it was revealed that students' problem-solving abilities varied based on Polya's problem-solving steps, with as many as 52.97% of high-ability students, 15.87% of moderate-ability students, and 30.16% of low-ability students. Then, it was revealed that students' problem-solving abilities differed based on their reasoning abilities (Fabby, 2015). Differences in reasoning ability result in problem-solving steps taken by students; students with high reasoning abilities also have very good problem-solving abilities based on Polya's problem-solving steps. Furthermore, it was revealed that there were differences in students' mathematical problem-solving abilities based on the learning approach used in the classroom (Osman et al., 2018; Son & Fatimah, 2020). The ability to solve mathematical problems of students who are taught with a visual thinking approach is better than that of students who are taught conventional learning. Based on some of the results of the research above, it is known that the different problem-solving abilities of students are influenced by several factors.

Based on the description above, the researcher was interested in knowing the students' mathematical problem-solving abilities based on Polya's problem-solving steps in terms of the logical-mathematical intelligence of the Acceleration class students at public middle-school 6 Sengkang.

2. METHOD AND DISCUSSION

This study uses a qualitative approach, which is intended to understand the phenomenon of what is experienced by research subjects holistically, by means of descriptions in the form of words and language, in a special natural context, and by utilizing various natural methods (Creswell & Creswell, 2017).

The type of research used in this research is descriptive, namely, research conducted to describe or explain in a systematic, factual, and accurate manner the current state of the object of research based on visible facts or as they are. Descriptive research does not provide treatment or changes to the research object but describes a condition as it is. So, this research is not directed to explain the relationship as in a hypothesis formulation and also does not predict the implications that will occur if a variable is manipulated.

In qualitative research, the researcher acts as the main instrument, assisted by supporting instruments, namely Logical-Mathematical Intelligence Tests, problem-solving ability tests, Interview Guidelines, and Field Notes.

The subjects in this study were students at public Middle School 6 Sengkang acceleration Class, who would then be given a logical-mathematical intelligence test. Then, according to the test results, students will be put into three levels of logical-mathematical intelligence: high logical-mathematical intelligence, moderate logical-mathematical intelligence, and low logical-mathematical intelligence. Furthermore, the number of subjects to be selected from each category of logical-mathematical intelligence depends on the comparison of the number of students included in it (proportional subject selection).

The data analysis steps in this study also used the Miles and Huberman qualitative data analysis model, which was carried out in 3 steps: data reduction, data presentation, and drawing conclusions followed by verification (Creswell & Creswell, 2017). To check the validity of the data in this study, a triangulation technique was used to collect it. Triangulation of different data collection techniques is a test of problem-solving skills through interviewing. The data from the problem-solving ability test results will later be matched with the data obtained from the interview results. Then conclusions are drawn from the results of the problem-solving ability test and the interview results.

3. RESULTS AND DISCUSSION

Results

Based on the results of the observations, it was determined that in the learning process in the classroom, the teacher applied a direct learning model with discussion and question-and-answer methods. In teaching, the teacher does not emphasize the concept until students are able to know what formula to use to solve the problem. The teacher also only gives 1 to 2 sample questions and then asks students to complete other questions that are similar to the sample questions. This is done because, in accelerated classes, teachers are required to teach the same material as in regular classes in a shorter time, or, in other words, the learning material is condensed. Thus, students are required to study independently outside of class hours in order to understand the material well.

In the following, the flow of problem-solving abilities of subjects with high, medium, and low logical-mathematical intelligence is presented for each problem-solving ability given.

3.1 Problem Solving Flow Problem Number 1

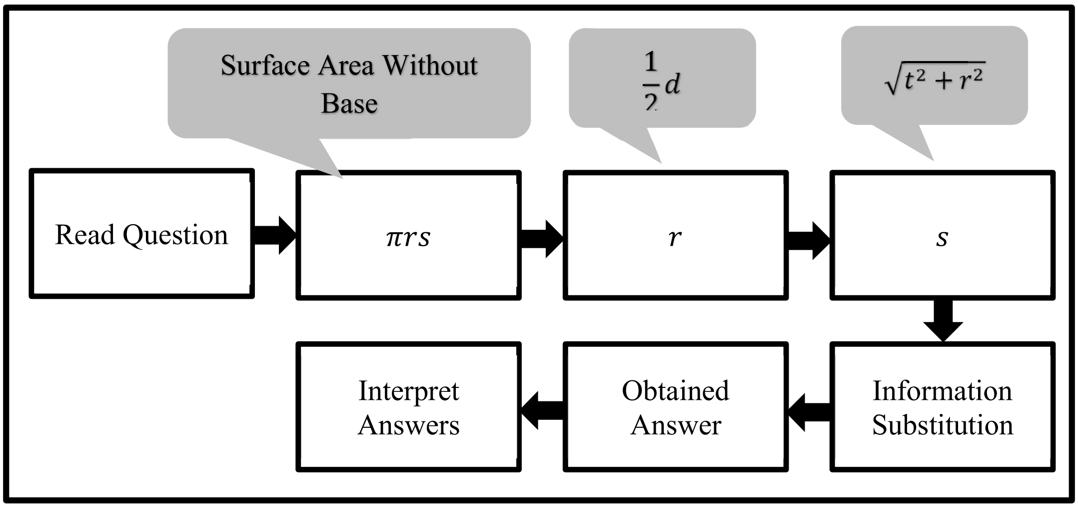

Figure 1. Flow of Subjects with High Logical-Mathematical Intelligence

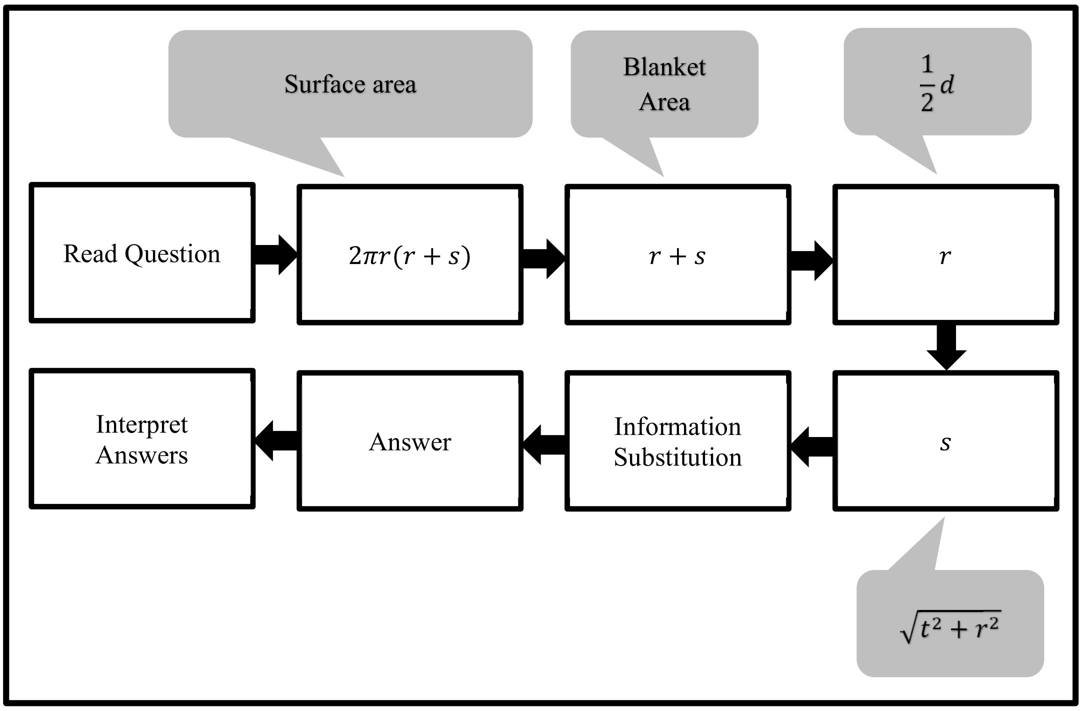

Figure 2. Flow of Subjects with Moderate Logical-Mathematical Intelligence

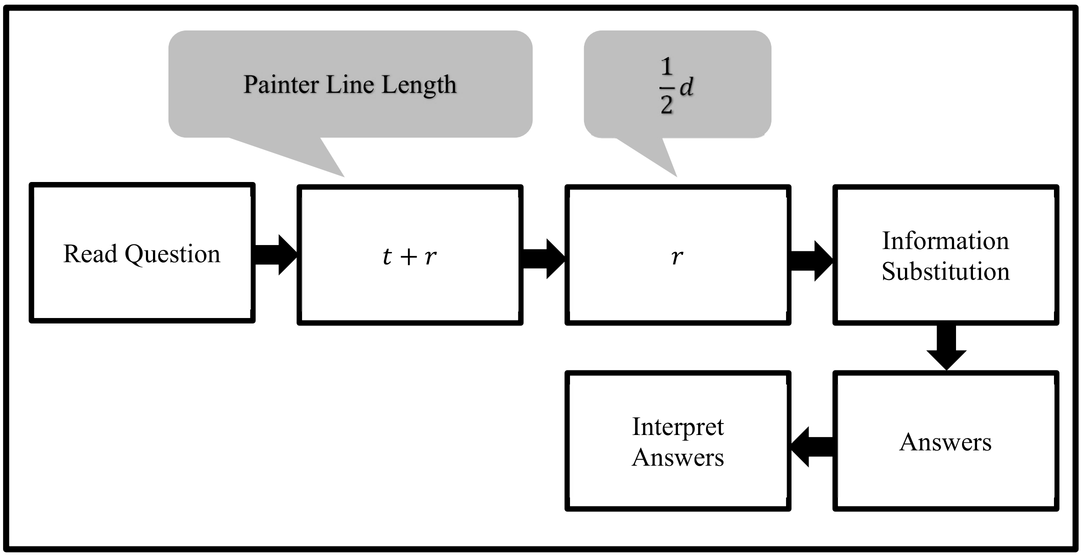

Figure 3. Flow of Subjects with Low Logical-Mathematical Intelligence

Based on the flow of problem-solving above, it appears that subjects with high and moderate logical-mathematical intelligence have differences in the steps to determine a problem-solving plan, especially in choosing the relevant formula to solve the problem correctly. In determining the relevant problem-solving plan to solve the problem correctly, subjects with high logical-mathematical intelligence are able to provide the right plan, but subjects with low logical-mathematical intelligence are making mistakes in determining the right plan. The mistake made by subjects with moderate logical-mathematical intelligence lies in an error in determining the formula for the surface area of a cone, which is then simplified into the formula for the area of a conical blanket.

Even so, the two subjects had the same understanding in the step of understanding the problem, namely finding the blanket area or the surface area of a cone without a base.

Then, subjects with low logical-mathematical intelligence are mistaken in understanding the problem, namely looking for the length of the cone painter line. The next mistake made by this subject was an error in determining a problem-solving plan that was in accordance with the problem he understood. The mistake made by a subject with low logical-mathematical intelligence lies in the wrong concept that the subject has about the length of the cone painter's line.

3.2 Problem Solving Flow Problem Number 2

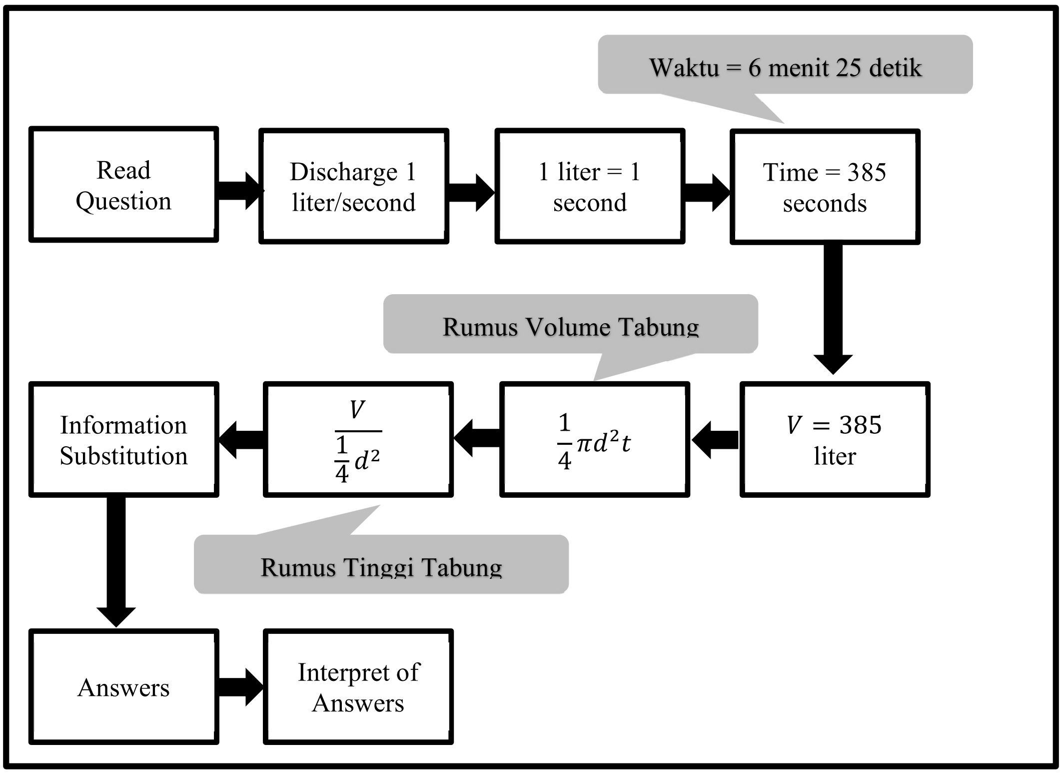

Figure 4. Flow of Subjects with High Logical-Mathematical Intelligence

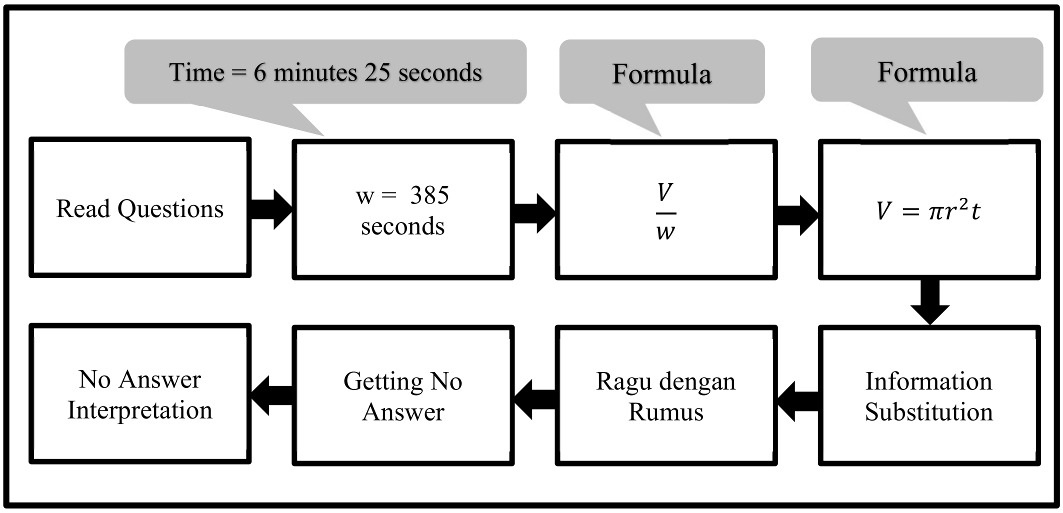

Figure 5. Flow of Subjects with Moderate Logical-Mathematical Intelligence

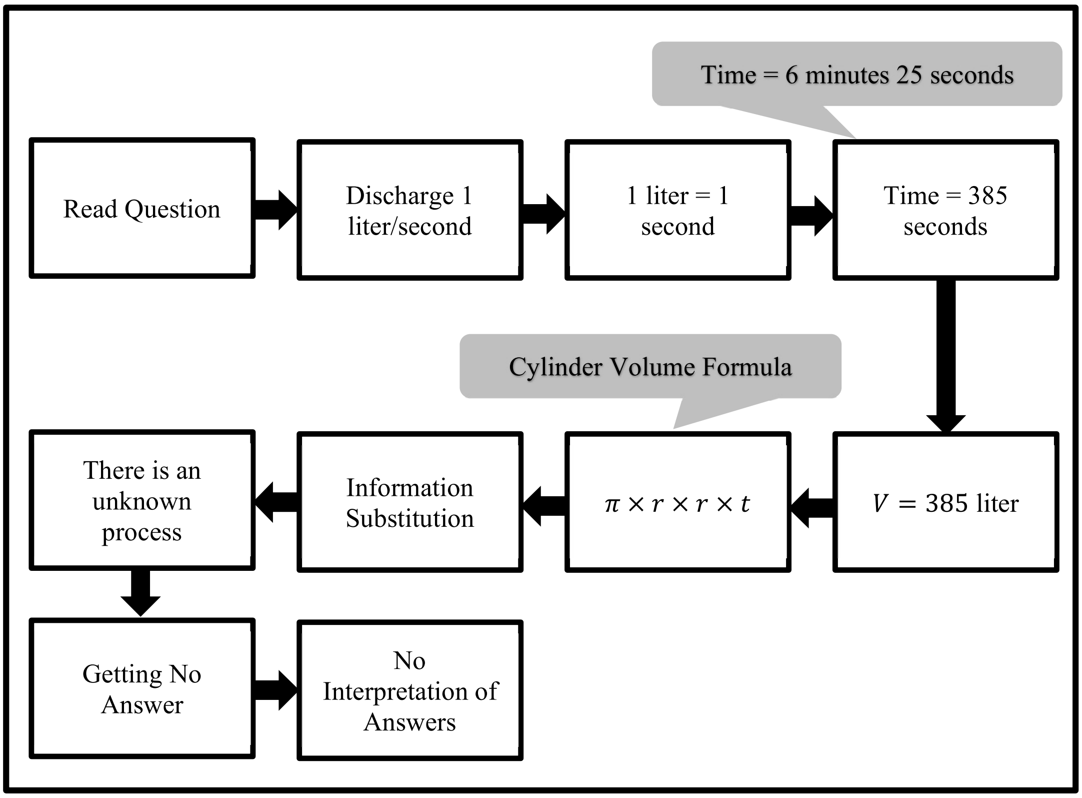

Figure 6. Flow of Subjects with Low Logical-Mathematical Intelligence

The problem-solving flow above shows that each subject understands the problem well. Subjects with high and low logical-mathematical intelligence have differences from subjects who have moderate logical-mathematical intelligence in terms of finding the volume value of the cylinder. Subjects with high and low logical-mathematical intelligence found the value of cylinder volume through a comparison associated with discharge and time, while subjects with moderate logical-mathematical intelligence found the value of cylinder volume through a discharge formula associated with volume and time. In formulating a problem-solving plan, all subjects were able to arrive at the formula for the volume of a cylinder, but only subjects with high logical-mathematical intelligence were able to arrive at the formula for finding the height of a cylinder.

For the next stage, only subjects with high logical-mathematical intelligence get answers or final results from implementing the steps of solving the problem, which is then followed by an interpretation of the answers. Subjects with moderate logical-mathematical intelligence are unable to continue their substitution process until they get an answer because they are unsure of the formula they have chosen, while subjects with low logical-mathematical intelligence are unable to continue their substitution process until they obtain an answer because there is an algebraic process they do not understand, so there is no interpretation of the answers of the two subjects.

Discussion

The results of the data analysis show that there is a link between logical-mathematical intelligence and students' mathematical problem-solving abilities. Logical-mathematical intelligence includes three abilities, namely the ability to pattern numbers, numerical skills, and logical abilities. These three abilities are related to the steps taken by students in solving problems.

Students with high logical-mathematical intelligence are able to carry out problem-solving steps well (Azinar & Munzir, 2020). Students recognize patterns and use logic to be able to analyze a given problem so that they are able to determine what is known, what is asked, and relevant problem-solving plans to solve the problem appropriately. Furthermore, students are able to substitute the information needed into a problem-solving plan and perform calculations correctly. It is very visible that each ability in logical-mathematical intelligence is influential in each step of problem-solving.

Students with moderate logical-mathematical intelligence are able to carry out steps to solve mathematical problems with some deficiencies or mistakes (Prastika et al., 2021). Students recognize patterns and use logic in order to be able to analyze the problems given so that they are able to determine what is known and what is asked in the questions. Students actually know what to do to solve a given problem but are constrained by the formula. Students do not remember the correct formula to use in solving a given problem. Then, in substituting the formula it provides, not all units with the same amount of information are equated or equalized. Furthermore, for calculations, students with moderate logical-mathematical intelligence are still not good enough; this can be seen from the errors in the calculations they do. Students are able to interpret the solution they get, even if it is not the right solution to the problem.

Students with low logical-mathematical intelligence are less able to follow the steps to solve mathematical problems correctly (Azinar & Munzir, 2020; Prastika et al., 2021). The ability to apply logic and analysis to students' problems is still lacking; this can be seen from the inability of students to determine what is being asked of the problem and develop relevant problem-solving plans to solve problems appropriately. Then students are able to substitute the information they need into a problem-solving plan but with some mistakes in the calculation process. So the right solution cannot be found. Students are able to interpret the solution they get, even if it is not the right solution to the problem.

So in general, it can be seen that the difference in students' logical-mathematical intelligence is clearly visible in the steps of understanding the problem and developing a problem-solving plan. For the step of carrying out the plan, all students made a few mistakes in the calculation process but were able to correct them in the step of checking again.

4. CONCLUSION

Based on the results and discussion stated above, in general, the differences in mathematical problem-solving abilities based on Polya's steps in terms of students' logical-mathematical intelligence are clearly visible in the step of understanding the problem, especially in the indicator of determining the right thing to ask, and the step of preparing a solution plan for the problem, especially on the indicators of compiling a relevant problem-solving plan to solve the problem appropriately.

Suggestions for future researchers, perhaps to be able to analyze other problem-solving theories or to be able to conduct research with the same fixed theme with different viewpoints, for example, students' thinking levels, cognitive styles, learning styles, and so on.

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