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Evaluating Mathematical Problem-Solving Skills in Primary School Students: Challenges and Insights from Polya's Framework

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ABSTRACT

Mathematical problem-solving skills are fundamental for fostering critical thinking, creativity, and the ability to address real-life challenges. However, many primary school students struggle with applying these skills effectively. This study aims to analyze the mathematical problem-solving abilities of Grade V elementary students using Polya's four-stage problem-solving model. This qualitative descriptive research involved 56 Grade V students from a primary school. Data were collected using a mathematical problem-solving test focused on numerical material. Students' responses were analyzed based on Polya's stages: understanding the problem, devising a plan, carrying out the plan, and looking back. The data analysis included data collection, reduction, presentation, and verification. The findings revealed that students showed the highest proficiency in understanding the problem (37%), followed by planning the solution (30%), solving the problem (23%), and rechecking their work (17%). These results indicate a declining trend in performance as students progress through each problem-solving stage. The study highlights students' limited abilities in applying strategic and reflective thinking, particularly in later stages of the problem-solving process. This suggests a need for instructional approaches that promote active engagement, systematic thinking, and creative problem-solving. Educators are encouraged to adopt learning models that support student-centered learning and facilitate the development of higher-order thinking skills.

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1. INTRODUCTION

Education plays a crucial role in guiding students to develop their knowledge and skills. Knowledge and skills are beneficial not only to students themselves but also to society as a whole. These abilities are an integral part that cannot be separated from human life. Through education, students can develop themselves to deal with existing changes. Education is a vital component that can be utilized for community development, the acquisition of knowledge and skills, encouraging critical thinking, and enabling informed participation in a rapidly changing world (Sofradzija, 2021).

Knowledge and skills can be obtained in the learning process. Learning mathematics is one of them. Students who learn mathematics in a contextualized manner develop logical and systematic thinking patterns. In learning mathematics, students are required to construct knowledge and apply mathematical concepts to solve existing problems. Fatahillah (2023) revealed that mathematics learning can hone cognitive, affective, and psychomotor abilities and foster conceptual understanding that is important for solving mathematical problems.

Mathematics learning constructs students' knowledge to enable them to solve problems and find solutions. According to Polya (1985), mathematical problem-solving involves attempting to find solutions to problems or difficulties in order to achieve a goal. Problem solving is accomplished through systematic steps or stages to find the most effective solution. The steps or stages of problem solving become indicators of this ability. Problem-solving indicators include 1) understanding the problem, 2) planning the solution, 3) solving the problem, and 4) checking again. The stage of understanding the problem is the student's ability to comprehend the information or gather the necessary data to determine the solution. The planning stage involves determining the strategy, which is a set of steps to be taken to solve the problem. The problem-solving stage consists of understanding the problem and planning a predetermined solution. The rechecking stage ensures that the problem-solving is correct regarding the presented problem.

Problem-solving indicators are used systematically to obtain solutions to problems encountered through mathematics learning. Mathematics learning presents contextual issues that are close to students' lives. Students are required to find the right solution to the problem presented. Learning mathematics through the Polya stage enables the development of mathematical problem-solving skills by presenting contextual problems. Students who possess this ability can easily solve and find the right solution to the problems they face. Through Polya's stages, learning activities enable students to understand the problem, plan a solution, solve the problem, and verify the solution. Through the Polya stage, students can systematically develop their mathematical problem-solving skills and enhance critical thinking abilities (Kusumaningrum et al., 2023).

Pebriyanti and Amelia (2023) in their research revealed that through Polya's stages, students are systematically able to improve their mathematical problem-solving skills. Polya's stages encourage students to think systematically and identify errors through structured approaches, such as understanding the problem, planning the solution, solving the problem, and rechecking the solution. Systematically, Polya's steps or stages develop students' abilities through a structured process in obtaining solutions. Students undergo a structured process of understanding the problem by constructing knowledge to find the right solution. The stages that students go through in finding the right solution teach the importance of having problem-solving skills.

Problem-solving ability is essential for students as they seek solutions to real-world problems. Kusumaningrum et al. (2023) revealed that students' mathematical problem-solving skills can be applied to overcome various problems and challenges in learning and real life. Problem-solving ability involves students actively engaging in higher-level thinking, enabling them to understand and use mathematical concepts in various contexts. By developing mathematical problem-solving skills, students can construct their knowledge and apply it to solve various real-life problems, producing appropriate and practical solutions.

In line with this research (Sundari et al., 2022), their research revealed that students who can solve mathematical problems independently can gain knowledge, skills, and experience. Students with strong mathematical problem-solving skills can achieve optimal learning outcomes and develop their critical thinking process. Through this process, students can solve the problems they face and find solutions in authentic contexts. Additionally, students with strong mathematical problem-solving skills can enhance their logical reasoning, adaptability, and creativity.

According to Panagdato et al. (2024), students with strong mathematical problem-solving skills are better equipped to effectively face life challenges in various situations, making it essential for students to possess these abilities in real-life situations. Students' ability to solve problems appropriately can make it easier for them to face challenges that may be encountered in real life. Students can provide solutions that enable problems to be solved effectively. Therefore, the ability to solve mathematical problems is essential for every student to face problems and challenges in real life.

The urgency of this research lies in the importance of mathematical problem-solving skills for students to master. Students with this ability may face challenges in providing the correct solution. So that in facing various challenges in real life, every student should have the ability to solve mathematical problems.

Fifty-six students in Class V of the Gugus V Tegalrejo Baru Primary School mostly had difficulty solving mathematical problems. The difficulty in solving mathematical problems is evident from the results of the mathematics problem-solving ability test on number material conducted at the Gugus V Tegalrejo Baru Primary School. The test consisted of 5 essay questions. The questions have been validated by expert judgment, and adjustments have been made based on the suggestions provided. They are then tested for reliability and validity using SPSS 29. The results obtained were Cronbach's alpha 0.753, indicating a reliable interpretation, and 5 out of 8 questions were deemed valid. Based on the question, it was then tested on grade V students of Tegalrejo Baru SDN Segugus, which consists of four public schools, and the results of the completeness criteria required further guidance.

Based on the problems that occurred, the researcher was encouraged to conduct an analysis of students' ability in solving mathematical problems. The research aims to examine the ability of elementary school students to solve mathematical problems through Polya's steps or stages, as a step towards addressing the problems experienced by students. The research focuses on errors made by students in the process of solving problems at the Polya steps or stages.

2. METHODS

The research employed qualitative methods to gain an understanding of the level of students' mathematical problem-solving skills. The analysis technique used the Miles and Huberman model with four stages, namely data collection, data reduction, data presentation and verification (Sugiyono, 2024) which was then carried out in the stages of collecting student test results, reducing data by examining student answers, presenting test data, and drawing conclusions from the research data.

The research was conducted in elementary schools of the Gugus V Tegalrejo Baru Primary School during the academic year 2024/2025, comprising four public schools with a total of 56 Grade V students. The research subjects consisted of 56 grade 5 students from four public schools in the Gugus V Tegalrejo Baru Primary School. All students participated in this study to gain a comprehensive understanding of mathematics problem-solving abilities based on Polya's stages. Data were obtained from students' written answers to the description questions, which were then analysed descriptively to reveal patterns and variations in problem-solving strategies. The problem-solving ability test instrument consisted of 5 essay questions on numerical material that had been tested for reliability and validity. The lattice of the problem-solving ability test instrument in this study is as follows:

Table 2. Lattice of Mathematics Problem-Solving Test Instrument

Learning Outcomes	Problem Indicators
Students demonstrate understanding and intuition of numbers in integers up to 1,000,000.	Students presented with a mixed arithmetic operation problem can determine the result of the arithmetic operation. Students with mixed arithmetic operation problems can complete the arithmetic operation. Presented with a story problem, students can determine the result of the problem. Presented with story problems, students can provide solutions to problems Presented with a story problem, students can determine the result of an arithmetic operation.

Data analysis was conducted descriptively and qualitatively, involving the description of students' mathematics problem-solving ability test results. Analysis includes data collection, data reduction, data presentation, and data verification. The research procedure consists of (1) preparation includes observation, problem identification and determination of data sources in following test questions, questionnaires and interviews, (2) the implementation stage is giving test questions, (3) the descriptive data processing stage from the documentation observation sheet, test questions and interviews, the next stage is to analyse the test results given through scoring guidelines.

Scoring guidelines for problem-solving skills utilize indicators of mathematical problem-solving, consisting of four stages. The indicators were developed into scoring guidelines used for student assessment, as follows:

Table 3. Scoring Guidelines for Mathematics Problem Solving

Indicators of Maths Problem Solving	Description	Score
1. understanding the problem,	understanding the problem, writing the information through the known and questioned statements in the problem	1
2. devising a plan,	planning the solution, writing mathematical sentences correctly and completely	1
3. solving the problem,	solving the problem, completing the proper procedure and correct calculation	1
4. checking back	checking back, writing the conclusion correctly, and checking the answer correctly	1

Data analysis of students' problem-solving ability test scores in this study used the percentage formula: score = $\frac{student}{ideal\ score}$ x 100. The qualification results of the calculation are then interpreted using percentages. The percentage has five categories as follows (Rachmawati & Adirakasiwi, 2021):

Table 4. Percentage of Problem-Solving Achievement

The Mastery Level	Criteria
81% - 100%	Very High
61% - 80%	High
41% - 60%	Medium
21% - 40%	Low
0% - 20%	Very Low

3. FINDINGS AND DISCUSSION

3.1 Findings

The research was conducted on 56 students in Class V of Elementary School Segugus V SDN Tegalrejo Baru, Kapanewon Ponjong, Gunungkidul Regency. The problem-solving ability test given to students consisted of 5 essay questions with numerical material. The data were then analyzed based on the scoring guidelines for mathematical problem-solving ability. There are four stages of the problem-solving process, namely (1) understanding the problem, (2) planning the solution, (3) solving the problem, and (4) checking again (Polya, 1985). The following represents the percentage of students' answers to questions 1 through 5.

Table 5. Percentage of Students' Answers Number 1

The Mastery Level	Correct	%	False	%
Understanding the problem	26	49%	27	51%
Devising a plan	31	58%	22	42%
Solving the problem	25	47%	28	53%
Checking back	9	17%	44	83%

Table 6. Percentage of Students' Answers Number 2

The Mastery Level	Correct	%	False	%
Understanding the problem	22	42%	31	58%
Devising a plan	12	23%	41	77%
Solving the problem	8	15%	45	85%
Checking back	5	9%	48	91%

Table 7. Percentage of Students' Answers Number 3

The Mastery Level	Correct	%	False	%
Understanding the problem	19	36%	34	64%
Devising a plan	14	26%	39	74%
Solving the problem	9	17%	44	83%
Checking back	6	11%	47	89%

Table 8. Percentage of Students' Answers Number 4

The Mastery Level	Correct	%	False	%
Understanding the problem	16	30%	37	70%
Devising a plan	13	25%	40	75%
Solving the problem	11	21%	42	79%
Checking back	12	23%	41	77%

Table 9. Percentage of Students' Answers Number 5

The Mastery Level	Correct	%	False	%
Understanding the problem	12	23%	41	77%
Devising a plan	8	15%	45	85%
Solving the problem	7	13%	46	87%
Checking back	12	23%	41	77%

Table 10. Percentage of Problem Solving Achievement based on Indicators Problem Solving Ability

Stage	Percentage	Category
Understanding the problem	45%	Medium
Devising a plan	37%	Low
Solving the problem	28%	Low
Checking back	21%	Low

The test results presented in Table 11 indicate that the stage of understanding the problem obtained a score of 37%. The score falls into the low category. Most students do not understand the information contained in the problem. Therefore, at this stage, the information written by students is often incomplete and sometimes incorrect. This stage is the initial stage, so if students at this stage of understanding the problem are wrong, it will result in the next stage.

The planning stage obtained a score of 30% with a low category interpretation. Students in developing a solution strategy often tend to be wrong, which is a result of a lack of understanding of the information. Most students do not write problems into mathematical sentences as a planning step. Students often struggle to determine how to plan a strategy for implementation.

The problem-solving stage obtained a score of 23% with a low category interpretation. Students cannot implement the solution process because, at the stage of understanding the problem and planning the solution, it is not carried out optimally and appropriately. The problem-solving stage is closely related to the previous stages. If the previous stage is not carried out properly, it will have an impact on problem-solving. So that at the stage of solving problems, students experience difficulties, and the calculations made are incorrect.

The last stage, namely rechecking, yielded a score of 17% with a very low category interpretation. Most students did not recheck the solution given to the problem presented. Many of the students solve the problem in the third stage. Students assume that the solution to the problem has been found. The following is an analysis of the majority of errors made by students in solving mathematics problem-solving ability test questions, focusing on one specific problem.

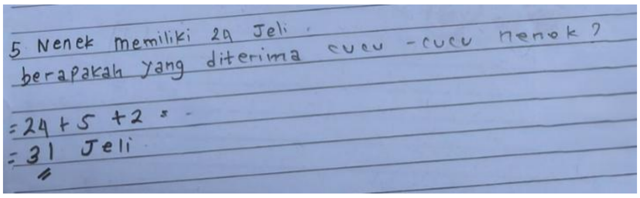

Figure 5. One Student's Answer to Question Number 5

Based on these results, students have understood some of the information and problems presented. However, the information is incomplete, and the problem is not well-suited, leading to misconceptions. As a result, the solution planning stage is not appropriate. Since the impact occurs at the problem-solving stage, the results found are incorrect. At the stage of rechecking the answer, students often fail to perform this step and do not draw a conclusion from the answer obtained.

3.2 Discussion

Based on the results of the item analysis, students' mathematics problem-solving skills fall into the low category. The pattern of errors made by students starts at the initial stage, namely the stage of understanding the problem. As many as 63% of students did not understand the information and problems given. The error led to misconceptions that persisted, causing errors in subsequent stages until the end. The stage used in this study employs Polya's mathematical problem-solving steps. Polya's stage consists of 4 steps or stages, namely 1) understanding the problem, 2) planning the solution, 3) solving the problem, and 4) checking again (Polya, 1985).

Mathematical problem-solving ability involves an effort to find solutions to challenges (Tririnika et. al, 2024). Solutions are found through interconnected stages and are done in a sequential, structured, and systematic manner. Polya's mathematical problem-solving stage consists of understanding the problem, making a plan, implementing the plan, and checking back is a related stage (Pradana, 2024). Therefore, if obstacles arise at one stage, they will impact the results of the next stage; therefore, the stages of solving mathematical problems must be completed correctly at every step.

Polya's stages are used to analyse errors made in solving problems (Suharti et al., 2021). The majority of errors made by students occur because they do not understand the information in the problem. Students often struggle to convert problem forms into mathematical sentences. Students are rarely given exercises on description problems, and work on problems in order and coherently. In addition, students often lack a solid understanding of basic mathematical concepts, particularly in number material. The learning process pays less attention to variations in the right learning model for developing mathematical problem-solving skills.

Students lack understanding of the information and problems presented. The majority of students do not understand the sentences in the problem. Therefore, the information obtained in the problem is often incomplete, which can lead to misconceptions. In line with the research of Wibowo et al. (2024), student errors begin with reading errors, misunderstandings of problems, errors in process skills, and incorrect final answers. Meanwhile, understanding problem information in mathematics is crucial for effective problem-solving (Luo & Yu, 2020).

The majority of students struggle to convert problem forms into mathematical sentences. In line with research conducted by Rozinita et al. (2023), it was revealed that errors occurred due to a lack of knowledge or understanding of information, as well as issues with accuracy and concentration. Meanwhile, the planning stage is the first step to perform calculations to find a solution. This happens because of the lack of practice problems that hone mathematical problem-solving skills, so that students struggle to devise the right solution plan to find a solution.

Students lack understanding of the basic concepts of mathematical number material. The majority of students at the planning stage have made mistakes in developing strategies. As a result, at the stage of implementing the plan, students will likely make mistakes in solving the problem. In line with Pebrianti et al. (2023), the mistakes made by students during calculations due to a lack of accuracy and errors in calculating were revealed. For students who successfully develop a solution plan but encounter issues during implementation, this is a common mistake. This is due to a lack of accuracy and incorrect use of the formula.

Additionally, students lack an understanding of basic concepts related to numerical material. Students often lack thoroughness in completing calculations due to incorrect calculation operations or missing steps (Putri et al., 2023). In addition, according to Abdullah et al. (2024), student errors in solving mathematical problems include errors in connecting concepts, operations, and building upon them.

Errors in calculating can be anticipated by rechecking the answer. However, most students did not check their answers. Students often feel that they have found the answers to problems. So it is not uncommon for students to stop only at the stage of implementing the plan. Even though this last stage is critical in ensuring the accuracy of the results. In line with Scheibe et al. (2023), rechecking answers at the stage of solving mathematical problems helps students ensure accuracy, produce the correct answer, and consider the possible answers they have generated.

The learning process pays less attention to variations in the right learning model for developing mathematical problem-solving skills. Mathematical problem-solving skills involve understanding, visualizing information, representing data, and planning solution steps (Upu et al., 2024). Learning carried out by students so far has focused on delivering concepts. Concepts are delivered passively, and student involvement is less dominant. Variations in models and strategies for learning are necessary, especially in developing mathematical problem-solving skills. Variations in learning models are significant and crucial for developing mathematics problem-solving skills. Students can be exposed to diverse approaches and solutions (Lee & Lai, 2024).

The problems that occur can be overcome through various strategies. One strategy that can be employed is to increase the practice of descriptive questions related to problem-solving. Presenting problems related to everyday life, choosing the right learning model with active student involvement, and providing feedback in every lesson appropriately.

Students can be given structured exercises of descriptive problems related to problem-solving. Exercises with a variety of different problems can help students recognise different types of problems and different ways of solving them. Practice with different types of problems significantly improves students' ability to recognise and solve mathematical problems (Choy & Dindyal, 2018).

Presenting problems in the context of everyday life. Students are given real-world problems that are relevant to their lives. This requires the application of mathematical concepts to find solutions. The problems presented can encourage students to think critically and creatively in solving problems. Mathematics learning strategies can enhance problem-solving skills through active engagement with real-world problems (Hasan, 2024).

Select a range of learning models that engage students in an active role. Learning through various group activities and discussions can improve students' mathematics problem-solving skills. These models can include cooperative learning, problem-based learning, and project-based learning models. One of the cooperative learning models that can be used is the Jigsaw-type cooperative model. The jigsaw-type cooperative learning model can improve students' mathematical problem-solving skills (Siregar & Khayroiyah, 2019).

Provide feedback in every lesson appropriately. Feedback is provided regularly at each stage of the problem-solving process. Students can be helped in assessing their understanding and correcting errors. Appropriate feedback can enhance mathematics problem-solving skills, particularly when students are guided to find solutions to problems (Fyfe & Brown, 2020).

4. CONCLUSION

The results of research conducted in class V elementary school with 56 students showed that the percentage of achievement of mathematical problem solving ability at the stage of understanding the problem was 37% with a low category interpretation, the planning stage was 30% with a low category interpretation, the problem solving stage was 23% with a low category interpretation and the stage of checking back was 17% with a very low category interpretation. Based on the results of this study, it is evident that students' overall mathematical problem-solving skills fall into the low category.

Mathematical problem-solving employs Polya's stages, which consist of four stages: the stage of understanding the problem, the stage of planning the solution, the stage of implementing the plan, and the stage of checking again. The issue of students' mathematical problem-solving ability needs to be addressed by educators to enhance the quality of learning. Some strategies that can be employed include learning by integrating mathematical problem-solving, varied and contextual problem exercises, guidance at the stage of planning solutions, receiving appropriate feedback, cooperation or discussion for solving problems, and developing process-based instruments.

Although the results of this study provide a clear picture of students' problem-solving skills, the study has limitations, particularly in terms of the scope of data, which is limited to written test results, and the context, which is confined to a single cluster. Therefore, further research with a data triangulation approach and more exhaustive coverage is highly recommended. It is hoped that this research will serve as a reference for educators to understand and effectively guide students through the learning process, thereby developing their mathematics problem-solving skills. Future research is recommended to employ triangulation methods, such as interviews or direct observation, and involve more schools to ensure more generalizable results. Further studies can also explore non-cognitive factors that influence students' problem-solving ability.

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