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ANALYSIS OF STUDENTS' MATHEMATICAL PROBLEM SOLVING ABILITIES BASED ON POLYA'S STAGES IN MATHEMATICS LEARNING IN GRADE IV AT SD 25 BANDA ACEH

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Abstract

The low level of mathematical problem-solving ability among elementary school students remains a challenge in mathematics learning, particularly in students' ability to plan strategies, carry out solution steps, and review their answers. This study aimed to describe and analyze students' mathematical problem-solving abilities based on George Polya's stages in mathematics learning for fourth-grade students at SD Negeri 25 Banda Aceh. This research employed a descriptive qualitative approach. The research subjects consisted of five students selected purposively. Data were collected through problem-solving tests and interviews, while data analysis included data reduction, data presentation, and conclusion drawing based on the indicators of each problem-solving stage, namely understanding the problem, planning the solution, carrying out the plan, and looking back. The results showed that, in general, students were able to understand the given problems, but they still experienced difficulties in planning and carrying out solution steps systematically. In addition, the looking back stage had not been carried out optimally by most students. Overall, students' mathematical problem-solving ability was categorized as moderate. This category indicates that students were able to fulfill some of the problem-solving indicators, but had not demonstrated consistent and optimal performance across all stages. Specifically, two students were able to complete all stages, one student experienced difficulties at the planning and implementation stages, while the other two students experienced difficulties at the planning, implementation, and looking back stages. These findings indicate the need to strengthen the planning, implementation, and reflection stages in the learning process so that students' mathematical problem-solving abilities can develop optimally.

Keywords: Mathematical Problem-Solving Ability, Polya's Stages, Mathematics Learning, Elementary School

Abstrak

Rendahnya kemampuan pemecahan masalah matematika di kalangan siswa sekolah dasar masih menjadi tantangan dalam pembelajaran matematika, khususnya dalam kemampuan siswa merencanakan strategi, melaksanakan langkah-langkah penyelesaian, dan meninjau jawaban mereka. Penelitian ini bertujuan untuk mendeskripsikan dan menganalisis kemampuan pemecahan masalah matematika siswa berdasarkan tahapan pembelajaran matematika George Polya untuk siswa kelas empat di SD Negeri 25 Banda Aceh. Penelitian ini menggunakan pendekatan kualitatif deskriptif. Subjek penelitian terdiri dari lima siswa yang dipilih secara purposif. Data dikumpulkan melalui tes pemecahan masalah dan wawancara, sedangkan analisis data meliputi reduksi data, penyajian data, dan penarikan kesimpulan berdasarkan indikator setiap tahapan pemecahan masalah, yaitu memahami masalah, merencanakan solusi, melaksanakan rencana, dan meninjau kembali. Hasil penelitian menunjukkan bahwa, secara umum, siswa mampu memahami masalah yang diberikan, tetapi mereka masih mengalami kesulitan dalam merencanakan dan melaksanakan langkah-langkah penyelesaian secara sistematis. Selain itu, tahap meninjau kembali belum dilakukan secara optimal oleh sebagian besar siswa. Secara keseluruhan, kemampuan pemecahan masalah matematika siswa dikategorikan sedang. Kategori ini menunjukkan bahwa siswa mampu memenuhi beberapa indikator pemecahan masalah, tetapi belum menunjukkan kinerja yang konsisten dan optimal di semua tahapan. Secara spesifik, dua siswa mampu menyelesaikan semua tahapan, satu siswa mengalami kesulitan pada tahap perencanaan dan implementasi, sementara dua siswa lainnya mengalami kesulitan pada tahap perencanaan, implementasi, dan refleksi. Temuan ini menunjukkan perlunya penguatan tahap perencanaan, implementasi, dan refleksi dalam proses pembelajaran agar kemampuan pemecahan masalah matematika siswa dapat berkembang secara optimal.

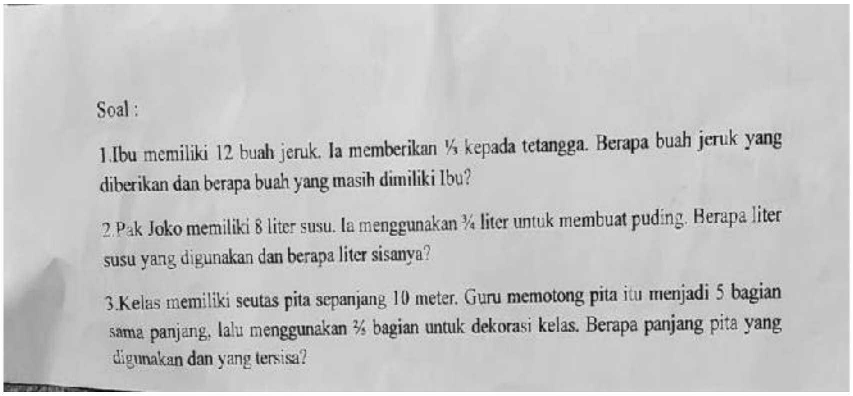
Kata kunci: Kemampuan Pemecahan Masalah Matematika, Tahapan Polya, Pembelajaran Matematika, Sekolah Dasar

INTRODUCTION

Elementary school students' mathematical problem-solving ability is still considered low and has become one of the major challenges in mathematics learning. Various studies indicate that students experience difficulties in understanding problems, determining solution strategies, and evaluating the results obtained, resulting in problem-solving processes that are not carried out systematically. This condition indicates that the learning process has not fully developed higher-order thinking skills, particularly in reasoning and problem-solving aspects (Madzkiyah et al., 2024; Munawwarah et al., 2024). In addition, the lack of habituation in using structured problem-solving strategies causes students to tend to seek answers directly without going through an in-depth analytical process (Fitriani, 2025). Therefore, an approach that can systematically guide students is needed, one of which is Polya's problem-solving stages, which include understanding the problem, planning the solution, carrying out the plan, and looking back, which have been proven effective in improving students' mathematical problem-solving abilities (Putri & Toyib, 2025). The phenomenon occurring in the field shows that many fourth-grade elementary school students still experience difficulties in understanding and solving mathematics problems. In line with Sari's findings in her study (2023), students' problem-solving abilities in arithmetic operations material were still low, with only 44% of students categorized as having "high" problem-solving ability. This condition indicates the need for intervention in the learning process to improve these abilities.

The results of the preliminary analysis of students' mathematical problem-solving abilities conducted on July 18, 2025, at SD Negeri 25 Banda Aceh showed a major obstacle in the aspect of understanding word problems. Based on the observations and evaluations, most students experienced difficulties in identifying important information and relating it to appropriate mathematical models or operations, resulting in an unsystematic problem-solving process. These findings indicate that students are not yet accustomed to integrating mathematical concepts with real-life contexts presented in the form of word problems. This condition is in line with recent studies stating that students' difficulties in mathematical problem-solving generally lie in the stages of understanding the problem and transforming information into mathematical models

(Fitriani, 2025; Madzkiyah et al., 2024). Therefore, more directed instructional efforts are needed to train students' problem-understanding abilities as a foundation for improving their mathematical problem-solving skills.


Soal :

1.Ibu memiliki 12 buah jeruk. Ia memberikan ⅓ kepada tetangga. Berapa buah jeruk yang diberikan dan berapa buah yang masih dimiliki Ibu?

2.Pak Joko memiliki 8 liter susu. Ia menggunakan ¾ liter untuk membuat puding. Berapa liter susu yang digunakan dan berapa liter sisanya?

3.Kelas memiliki seutas pita sepanjang 10 meter. Guru memotong pita itu menjadi 5 bagian sama panjang, lalu menggunakan ⅖ bagian untuk dekorasi kelas. Berapa panjang pita yang digunakan dan yang tersisa?

Figure 1.1 Problem-Solving Ability Test

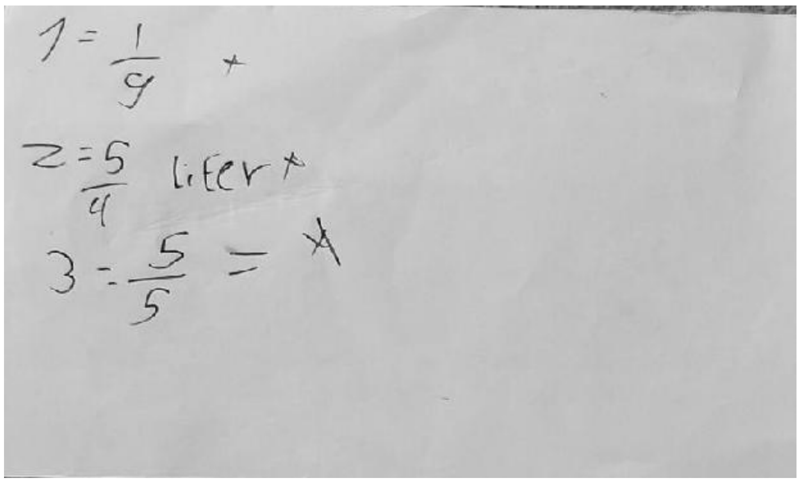


Figure 1.2 Students' Answers

Based on Figure 1.2, it can be seen that students were able to understand some of the information presented in the problem; however, they still experienced difficulties in arranging the solution steps systematically. This indicates that students' abilities in the planning and implementation stages of problem-solving have not yet developed optimally.

Based on the results of the preliminary observation in fourth-grade mathematics learning, it was found that students still experienced difficulties in solving word problems, particularly in understanding problems comprehensively and applying problem-solving steps systematically according to Polya's stages. In practice, some students tended to write the final answer directly without explaining the planning and implementation processes in a sequential manner, and they had not consistently rechecked the results obtained. This condition indicates that the implementation of problem-solving stages in the learning process has not yet been carried out optimally.

The results of interviews with students and teachers revealed that these difficulties were influenced by students' low understanding of Polya's stages as well as their limited ability to comprehend mathematical terms in word problems. In addition, the lack of habituation and explicit guidance in applying each stage of problem-solving caused students to be unaccustomed to thinking systematically and reflectively. These findings are consistent with recent studies showing that students' difficulties in mathematical problem-solving generally lie in the stages of understanding problems and planning solutions systematically (Madzkiyah et al., 2024; Wahab et al., 2024; Putri & Toyib, 2025). Therefore, it is necessary to strengthen instructional strategies oriented toward the consistent implementation of Polya's stages.

Polya's theory, developed by George Polya, is a systematic approach to problem-solving that is highly relevant to be applied in elementary schools, particularly in fourth-grade mathematics learning. This theory consists of four main steps: understanding the problem, planning a solution, carrying out the plan, and looking back. By following these steps, students can approach mathematical problems in a structured manner, which in turn can improve their understanding of mathematical concepts. The implementation of this theory helps students not only solve problems but also understand the mathematical thinking processes underlying them. Therefore, the application of Polya's theory in fourth-grade mathematics learning through a qualitative approach not only assists students in solving mathematical problems but also equips them with thinking skills needed to face future challenges. Through a better understanding of the problem-solving process, students can become more confident in their mathematical abilities, which can ultimately improve their overall academic achievement.

The qualitative method in Polya's theory enables teachers to observe and analyze how students think and solve problems. Through this approach, teachers can identify the difficulties faced by students and provide constructive feedback. For example, in the context of mathematics, students can be encouraged to discuss various ways of solving problems so that they can understand mathematical concepts more deeply. Research shows that qualitative methods can increase student engagement and facilitate more meaningful learning. Several studies supporting the implementation of Polya's theory in elementary mathematics learning include research conducted by Andriani (2024), which states that the use of Polya's steps in mathematics learning can improve students' learning outcomes.

This study found that students taught using the Polya approach showed a significant improvement in their understanding of mathematical concepts compared to students who did not use the approach. In addition, Pratama (2025) also explained that the implementation of qualitative methods in mathematics learning can help students develop critical and creative thinking skills. The importance of this study lies in the effort to understand how fourth-grade students at SD Negeri 25 Banda Aceh apply Polya's stages in solving mathematics problems. The results of this study are expected to provide a clear description of students' level of understanding and ability in overcoming mathematical problems.

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METHODS

This study employed a qualitative approach with a descriptive method because it aimed to gain an in-depth understanding of students' mathematical problem-solving abilities based on the processes demonstrated in solving problems. This approach was used to reveal how students understand problems, plan solutions, implement strategies, and carry out rechecking according to Polya's stages through the analysis of students' work and interviews. In this study, the researcher acted as the key instrument who directly collected and analyzed data in a natural learning situation, so that a comprehensive description of students' difficulties at each stage of problem-solving could be obtained (Sugiyono, 2024; Creswell & Creswell, 2024).

The descriptive method was used to systematically, factually, and accurately describe students' mathematical problem-solving abilities based on Polya's stages, namely understanding the problem, planning the solution, carrying out the plan, and looking back. Through this method, the researcher sought to provide an in-depth description of students' thinking processes and to identify the difficulties experienced at each stage of problem-solving.

This study was conducted with fourth-grade students at SD Negeri 25 Banda Aceh. The research subjects consisted of five students selected purposively based on the results of a mathematical problem-solving ability test by considering variations in ability categories, namely high, medium, and low. The selection of these categories aimed to obtain a more comprehensive description of students' ability profiles at each ability level. The number of subjects, consisting of five students, was determined based on the consideration of the qualitative approach, which emphasizes the depth of data analysis, thereby enabling in-depth exploration of information through students' work results and interviews.

The data collection techniques in this study included tests, interviews, and documentation. Tests were used to obtain data regarding students' mathematical problem-solving abilities through word problems on fraction material. Interviews were conducted to explore in depth the students' thinking processes and the difficulties they experienced at each stage of problem-solving. Meanwhile, documentation was used to complement the research data in the form of students' work results and other relevant documents.

The research instruments used in this study included test instruments, interview guidelines, and documentation sheets. The test instruments were developed based on the indicators of Polya's stages, namely understanding the problem, planning the solution, carrying out the plan, and looking back. The interview guidelines were used as a guide to explore information regarding students' thinking processes and difficulties, while the documentation sheets were used to collect supporting data in the form of students' work results.

The data analysis technique in this study referred to the Miles and Huberman model, which includes data reduction, data presentation, and conclusion drawing. Data reduction was carried out by selecting and focusing on data relevant to the research objectives, then the data were presented in the form of systematic descriptions to facilitate understanding of students' ability patterns. Furthermore, conclusion drawing was conducted through the interpretation of the presented data and continuously verified to ensure the validity and consistency of the research findings.

RESULTS AND DISCUSSION

Based on the results of tests and interviews with five fourth-grade students, data were obtained regarding students' mathematical problem-solving abilities based on Polya's stages, namely: (1) understanding the problem, (2) planning the solution, (3) carrying out the plan, and (4) looking back. The analysis was conducted through the reduction of interview data, the presentation of data in the form of descriptions for each subject, and conclusion drawing based on the achievement of indicators at each stage.

Research Results

1. Results of Students' Mathematical Problem-Solving Ability Test

Based on the results of tests conducted on five fourth-grade students, mathematical problem-solving abilities were analyzed using George Polya's stages, which include understanding the problem, planning the solution, carrying out the plan, and looking back. The analysis results showed variations in the level of indicator achievement among the students.

In general, two students (ML and RA) were able to fulfill all indicators in all four stages and were therefore categorized as having high ability. Both students demonstrated the ability to understand problems accurately, design appropriate strategies, carry out procedures systematically, and recheck their results.

One student (SA) was categorized as having moderate ability because the student was able to understand the problem and perform reflection, but still experienced hesitation in planning the solution and made procedural errors during the implementation stage.

Meanwhile, the other two students (AB and AR) were only able to fulfill the indicators at the stage of understanding the problem. Their limitations in planning strategies, carrying out procedures, and rechecking results indicated that their problem-solving abilities were categorized as low.

2. Results of Student Interviews

The interviews were conducted to strengthen the findings from the tests, particularly on the stages that had not yet been achieved. Based on the analysis, students' difficulties mainly occurred in the stages of planning the solution, carrying out the plan, and looking back.

Students in the low category (AB and AR) generally did not yet understand the basic concepts and procedures for solving fraction problems. The difficulties encountered included the inability to determine solution strategies, confusion in selecting appropriate operations, and errors in the calculation process. In addition, both students were not accustomed to rechecking their work because they assumed that the answers they obtained were already correct.

Meanwhile, the student in the moderate category (SA) demonstrated a better understanding but still experienced hesitation in determining fraction elements such as numerators and denominators. Procedural errors still occurred at the initial stage, but these could be corrected after guidance was provided, and the student had begun to reflect on the results of the work. These findings indicate that the students' main weaknesses lie in procedural understanding and reflective abilities in problem-solving.

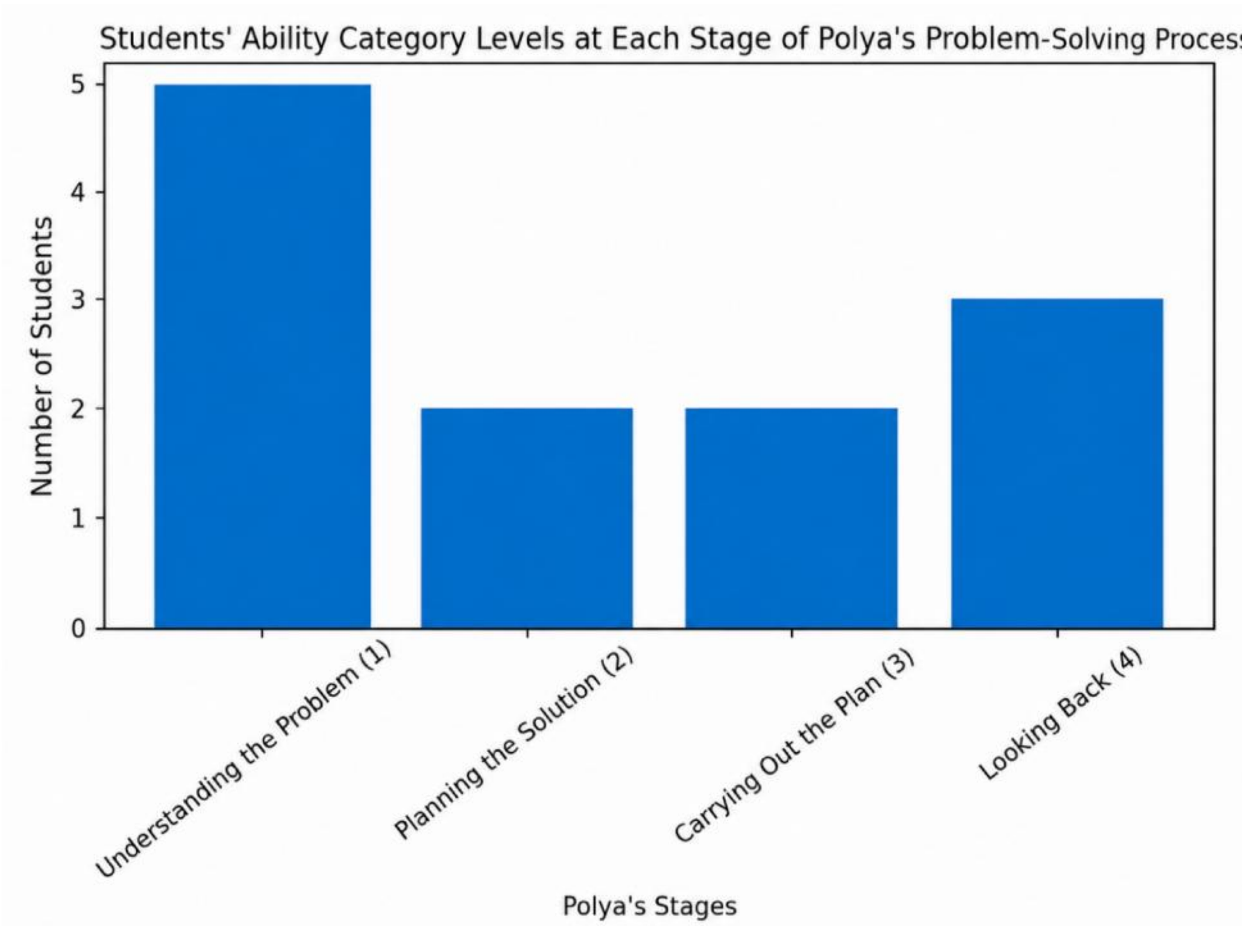

Figure 1: Students' Ability Category Levels at Each Stage of Polya's Problem-Solving Process

Figure 1 shows the distribution of students' mathematical problem-solving ability levels at each stage of George Polya's problem-solving process, namely understanding the problem, planning the solution, carrying out the plan, and looking back. Based on the figure, it can be seen that most students were able to achieve the stage of understanding the problem well. This is indicated by the dominance of the high category at the initial stage. However, at the stages of planning and carrying out the solution, there was a decline in students' ability levels, marked by an increase in the number of students in the moderate and low categories.

A more significant decline was observed at the stage of carrying out the plan, where some students still experienced procedural errors in the calculation process. Furthermore, at the looking back stage, students' abilities were also relatively low because some students were not yet accustomed to rechecking the results they obtained. Overall, the figure indicates that although students already possessed basic abilities in understanding problems, they still required reinforcement in the stages of planning, implementation, and reflection so that their mathematical problem-solving abilities could develop optimally.

Discussion

The results of the study showed that the mathematical problem-solving abilities of fourth-grade students at SD Negeri 25 Banda Aceh based on George Polya's stages were in the moderate category. This condition can be seen from the uneven distribution of students' abilities at each stage of problem-solving. In general, all students were able to achieve the stage of understanding the problem, but they still experienced difficulties in planning the solution, carrying out the plan, and looking back at the results of the solution. These findings indicate that students found it easier to understand the information presented in the problem than to apply solution strategies systematically.

At the stage of understanding the problem, all research subjects were able to identify the known and asked information in the word problems. Students were also able to restate the content of the problem in their own words. This indicates that students' abilities in reading, understanding the context of the problem, and interpreting basic information had developed quite well. The ability to understand the problem is an important initial foundation in problem-solving because without proper understanding, students will experience difficulties in the following stages. Thus, students' achievement at this stage shows that the learning process had helped students recognize important elements in mathematical problems.

Differences in ability began to appear at the stage of planning the solution. Students in the high category were able to determine relevant strategies, such as selecting appropriate fraction operations and arranging solution steps systematically. In contrast, students in the moderate and low categories still experienced confusion in determining solution methods. Some students had not yet been able to connect the known information with the mathematical concepts required. This condition indicates that the ability to plan strategies requires critical thinking skills and the ability to relate previously learned concepts to new situations.

At the stage of carrying out the plan, students in the high category were able to solve problems accurately and systematically. However, students in the moderate and low categories still showed procedural and conceptual errors, particularly in fraction operations. These errors indicate that students had not fully mastered the basic concepts and were less careful in performing calculations. The implementation stage requires not only conceptual understanding but also accuracy, consistency in procedures, and good procedural skills. Therefore, continuous practice is highly necessary so that students become accustomed to applying solution strategies correctly.

The looking back stage was the least achieved stage. Only students in the high category independently reviewed their answers by checking the solution steps and final results. Most of the other students stopped immediately after obtaining an answer without ensuring its correctness. These findings indicate that students' reflective and metacognitive abilities were still low. In fact, the looking back stage is important for fostering critical thinking habits, evaluating the accuracy of processes, and identifying possible errors.

The results of this study are consistent with various previous studies stating that elementary school students are generally more capable at the stage of understanding problems than at the stages of planning, implementation, and evaluation. Difficulties at these stages indicate that mathematics learning still tends to focus on final answers rather than students' thinking processes. Therefore, teachers need to develop learning activities that emphasize the complete problem-solving process.

The implications of this study indicate that teachers need to implement problem-based learning by consistently integrating Polya's stages. Teachers can guide students in planning solutions, provide scaffolding according to students' needs, train students to explain the reasons for using certain strategies, and encourage students to reflect through questions such as "Are the steps used appropriate?" or "Is there another simpler way?". Thus, students' mathematical problem-solving abilities can develop optimally, and students will not only be able to solve problems procedurally but also understand concepts more deeply.

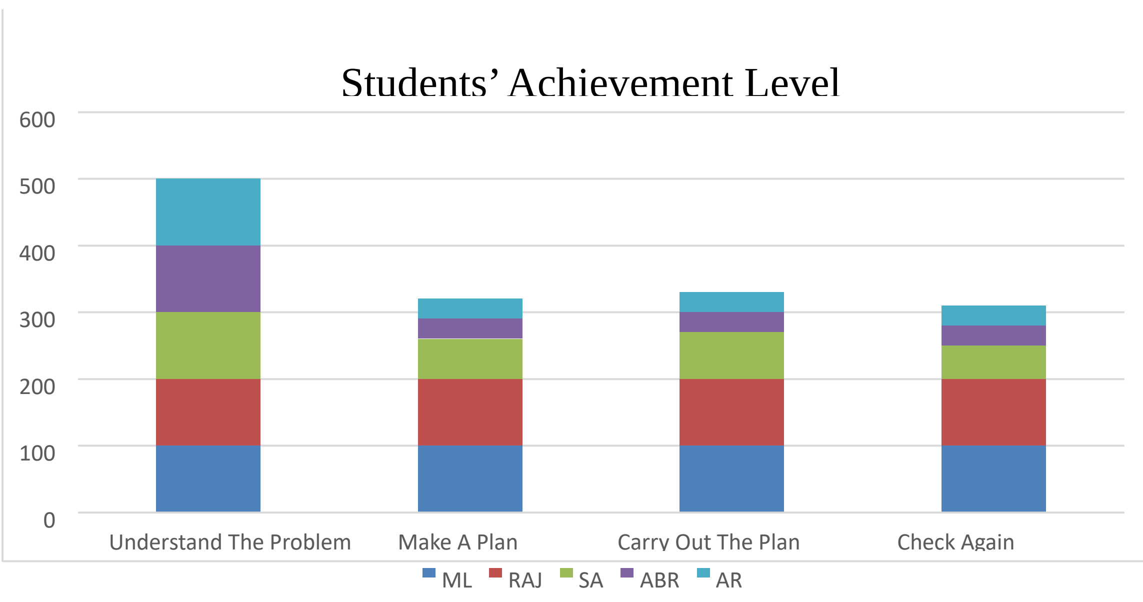

Figure 2: Number of Students Achieving the Good Category at Each Stage of Polya's Problem-Solving Process

Figure 2 shows that the highest number of students achieving the good category was found at the stage of understanding the problem, followed by a decline at the stages of planning the solution and carrying out the plan, with the lowest achievement occurring at the looking back stage based on George Polya's stages. This indicates that students still experienced difficulties in the stages of planning, implementation, and reflection, even though their ability to understand problems was relatively good.

Based on the reduction and presentation of test data as well as in-depth interviews with the five research subjects, it was found that not all students were able to implement George Polya's problem-solving stages completely and systematically. Specifically, three students, namely AB, AR, and SA, demonstrated limitations in developing problem-solving abilities at the stages of planning, implementation, and reflection. At the stage of understanding the problem, these three students were generally able to identify the known and asked information in the word problems. This indicates that conceptually they had an initial understanding of the problem context. However, this understanding was still superficial because it was not fully followed by the ability to connect information with relevant mathematical concepts. From a qualitative perspective, this condition indicates that students were able to reproduce information but had not fully internalized the meaning of the problem structure. These findings are consistent with Nurdalilah's research, which states that most elementary school students are able to understand basic information in word problems but still experience difficulties in relating that information to appropriate mathematical concepts.

More significant difficulties emerged at the stage of planning the solution. AB and AR were unable to determine appropriate strategies when dealing with fraction operations and showed confusion in determining the initial steps of the solution. Meanwhile, SA demonstrated hesitation in distinguishing numerators and denominators, resulting in solution plans that were not yet fully systematic. These findings indicate that strategic thinking and procedural planning abilities had not yet developed optimally in these three students. In qualitative analysis, this condition can be interpreted as weak mathematical representation skills and a lack of connection between concepts and problem-solving procedures. These findings are in line with Minarni's study, which states that the ability to design strategies is an important component of mathematical problem-solving, and students with insufficient conceptual understanding tend to experience difficulties in planning solution strategies.

At the stage of carrying out the plan, AB and AR made procedural errors indicating misconceptions, such as mistakes in fraction multiplication operations and errors in determining the structure of numerators and denominators. These errors not only reflect technical mistakes but also indicate that strong conceptual understanding of fractions had not yet been formed. Meanwhile, although SA initially made mistakes, the student was able to correct the answers after receiving stimulus or guidance from the researcher. This condition indicates that SA possessed fairly good cognitive potential but still required guidance or scaffolding in the problem-solving process. These findings are consistent with Anita Lie's research, which states that providing appropriate stimulus or guidance can help students build conceptual understanding and improve mathematical problem-solving abilities.

At the looking back stage, AB and AR did not show any initiative to reflect on the results of their work. Both students tended to stop at the final answer without verifying either the procedures or the calculation results. SA was able to recheck the answers, but only after receiving prompting questions from the researcher. Qualitatively, these findings indicate that students' metacognitive abilities, particularly in the aspects of self-monitoring and self-evaluation, were still relatively low. In fact, the reflection stage is an important component in the problem-solving framework because it functions to ensure the accuracy of results while also deepening students' conceptual understanding. This is also supported by the research of Tatag Yuli Eko Siswono, which states that reflection and self-evaluation abilities are important parts of mathematical thinking processes in problem-solving.

Overall, the qualitative analysis of the three subjects shows that the main obstacle faced by students does not lie in the stage of understanding the problem, but rather in the process of transforming that understanding into systematic solution strategies and in the ability to reflect on the results of the solution. Therefore, strengthening mathematics learning needs to focus on several main aspects: (1) explicit training in planning problem-solving strategies, (2) habituation in using appropriate mathematical representations in solving problems, and (3) development of students' metacognitive abilities through structured reflection activities in the learning process. These findings emphasize that elementary school students' mathematical problem-solving abilities are influenced not only by conceptual mastery but also by strategic and reflective thinking skills that need to be continuously developed in mathematics learning.

CONCLUSION

Based on the results of the study involving five fourth-grade students at SD Negeri 25 Banda Aceh, students' mathematical problem-solving abilities were generally categorized as moderate. All students were able to understand the problems well, namely by identifying the known and asked information in the questions. However, some students still experienced difficulties at the stages of planning solutions, carrying out solution steps, and looking back at their answers. This indicates that students' higher-order thinking skills still need to be improved. Therefore, mathematics learning should not only emphasize understanding problems but also systematically train students in planning strategies, implementing solutions, and reflecting on the results obtained. The consistent application of George Polya's stages can help improve elementary school students' mathematical problem-solving abilities.

This study provides benefits for journal readers across time. In the past, this study strengthens theories and previous research findings stating that students' main difficulties in mathematics lie in the stages of strategy development and result evaluation. In the present, the findings of this study can serve as a reference for teachers, university students, and researchers in designing more effective mathematics learning through the use of problem-solving models, worksheets based on Polya's stages, as well as the provision of scaffolding and reflective exercises.

In the future, this study is expected to become a foundation for the development of innovative mathematics learning that emphasizes critical, strategic, and reflective thinking skills, and to serve as a reference for further research aimed at improving the quality of mathematics learning at the elementary school level and beyond.

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