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# Implementing Polya's Problem-Solving Framework to Improve Word Problem Solving in Secondary School Mathematics

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**Abstract:** This study explores the effectiveness of the Polya Problem Solving Method in improving students' ability to solve word problems in mathematics at SMPN 17 Malang, Indonesia. The main objective is to determine whether this method can improve students' problem-solving abilities in the context of a linear equation system with two variables. A Classroom Action Research (CAR) approach is used, with two implementation cycles. Data was collected through pre- and post-test tests, classroom observations, and student interviews. These findings show a significant improvement in student performance, with the percentage of students meeting the Minimum Completeness Criteria (MCC) increasing from 36.3% in the pre-test to 84.84% after Cycle II. In addition, student engagement and teacher effectiveness increased markedly, especially in the second cycle, highlighting the importance of personalized support and active learning strategies. The results show that the Polya method can be very effective in fostering critical thinking and problem-solving skills in mathematics. This study contributes to the existing literature by demonstrating the benefits of structured problem-solving methods in Indonesian secondary education. Further research is recommended to explore the long-term effects of this method and its application in different educational contexts.

## INTRODUCTION

Math education plays an important role in students' cognitive development and their ability to apply critical thinking skills to solve real-world problems. One of the most challenging aspects of math education, especially at the high school level, is solving word problems. Word problems not only require the application of mathematical operations but also involve interpreting the context of the problem, understanding relevant information, and choosing the right strategies to solve the problem. Research shows that students often struggle with these types of problems due to their complex language, which adds a layer of difficulty in translating narratives into mathematical models (Polya, 2014)

The Polya method is built on a four-step process: understanding the problem, drawing up a plan, executing the plan, and evaluating the solution. A number of studies have shown the effectiveness of this structured approach in improving problem-solving abilities (M. Abdullah et al., 2020; Kaur & Gan, 2021a). However, despite its widespread use, there are still challenges in applying this method in real-world educational settings, especially in secondary schools in Indonesia. Previous research has shown that although the Polya method is effective in fostering problem-solving skills, its application in Indonesian classrooms is still underexplored(Sumarni & Amin, 2021). This gap in the literature

underscores the need for further research to examine how the Polya method can be adapted and utilized effectively in the context of Indonesian education.

The main research problem discussed in this study is the difficulties that students face when solving word problems in mathematics. At SMPN 17 Malang, many students have difficulty with the interpretation of math word problems, which affects their ability to solve them correctly. These challenges are exacerbated by limited student engagement with the subject, especially when teaching methods rely heavily on memorization and algorithmic procedures, rather than fostering critical thinking and active problem-solving (D. Wulandari et al., 2021). Given these issues, this study aims to explore the application of the Polya Problem Solving Method to improve students' ability to solve word problems in mathematics, especially in the context of Indonesian secondary education.

Several common solutions to improve problem-solving abilities in mathematics have been proposed in the literature. One widely recognized approach is the use of structured problem-solving frameworks that guide students through the process of understanding and solving word problems (M. A. Abdullah et al., 2020). This framework not only provides a systematic approach but also helps students break down complex problems into more manageable steps. Additionally, incorporating real-life context into word problems has been suggested as a way to increase student engagement and make math concepts easier to connect (Wang & Zhang, 2022). While these general solutions are valuable, there is limited research on the specific application of the Polya method in Indonesian classrooms, especially in secondary education.

A more specific approach, supported by ongoing research, is the application of the Polya Problem-Solving Method in mathematics education. Studies have shown that when students follow the Polya method, they are more successful in solving problems, identifying relevant information, and choosing the right math strategies (Kaur & Gan, 2021b). For example Abdullah et al (2020) found that the Polya method encourages active engagement with the problem-solving process, leading to better understanding and better outcomes. These findings are consistent with research showing that students taught with the Polya method develop stronger problem-solving skills, which can be transferred to other fields of study(Seah & Lee, 2020b). However, despite these promising results, the application of the Polya method in the context of Indonesian education, particularly in Malang, remains an area that requires further exploration.

Although the use of the Polya Problem-Solving Method in mathematics education has been well documented in various international settings, there is a striking gap in the literature regarding its specific application in Indonesia, especially in secondary education. Previous research has not adequately addressed how the Polya method can be integrated into the pedagogical practices of Indonesian teachers to improve students' problem-solving skills (Fahmi & Arif, 2021). In addition, there is limited empirical research focusing on the effectiveness of this method in Indonesian classrooms, particularly in Malang, where students' educational environment, teaching strategies, and cognitive abilities can present unique challenges. This gap in the literature highlights the need for research to examine how the Polya method can be adapted to the needs of Indonesian students, especially in solving word problems.

The purpose of this study is to evaluate the effectiveness of the Polya Problem Solving Method in improving students' ability to solve word problems, especially in the context of high school settings at SMPN 17 Malang. This study seeks to assess the impact of this method on students' ability to solve word problems and contributes to the broader literature on the effectiveness of the Polya method in diverse educational contexts. The novelty of this research lies in its focus on Indonesian secondary school students, especially in Malang, a field that has not been studied much in previous research. This study aims to provide empirical evidence on how the Polya method can be adapted and used to improve students' problem-solving skills in the context of Indonesian education. The scope of this study is limited

to the use of the Polya method in solving word problems, with its effectiveness evaluated through pre- and post-test assessments, student interviews, and classroom observations.

## METHOD

It contains the type of research, the time and place of the research, the target, the research subject, the procedure, the data and instruments, as well as the data collection technique, as well as the data analysis technique and other matters related to the research method. Objectives, research subjects, procedures, data and instruments, as well as data collection techniques, as well as data analysis techniques and other matters related to research methods can be written in sub-sub-chapters, with sub-sub-headings. Sub-subheadings do not need to be noted, but are written in lowercase letters with capital letters, TNR-11 is not bold, left-aligned.

The study uses a Classroom Action Research design, which is an approach that allows teachers to reflect on their own practice while actively engaging in the research process. CAR focuses on real-time improvement for teaching and learning practices through a continuous cycle of action and reflection. This design involves four main stages: planning, action, observation, and reflection (Kemmis & McTaggart, 2000). This cycle is repeated until a predetermined goal or success criterion is achieved.

In this study, the research was conducted in two cycles. Cycle I aims to identify initial problems related to students' problem-solving abilities, while Cycle II focuses on improving students' understanding and problem-solving skills through the Polya method. Each cycle includes planning and preparing teaching materials, conducting teaching sessions, observing student behavior and performance, and reflecting on the effectiveness of teaching methods.

**Participants**

The participants of this study were 33 students from class VIII B SMPN 17 Malang. The students consisted of 15 males and 18 females, all of whom were enrolled in math subjects. These students were selected based on their typical performance in solving word problems, which have been identified as major areas of difficulty. The samples were chosen deliberately, as the students were observed struggling with problem solving stories, which made them ideal candidates for the study of the effectiveness of the Polya Problem Solving Method.

In addition to students, the research involved collaboration with math teachers, who were instrumental in implementing the Polya method in the classroom. Teacher involvement is essential in ensuring the successful implementation of methods and data collection related to student learning outcomes. The study also involved two colleagues who acted as observers, helping to document and evaluate teacher and student activities during the teaching process.

**Data Collection Methods**

Several data collection methods are used to gather information about students' progress and the effectiveness of the Polya method in improving their problem-solving abilities. The primary data sources for this study are tests, observations, field notes, and documentation. Each of these methods was carefully selected to provide comprehensive and reliable data on the application of the Polya method.

**Pre and Post Test Assessment**

The test is used to measure students' understanding and ability to solve word problems. Pre-tests are conducted before the application of the Polya method to assess students' initial problem-solving skills. This test contains word problems related to the topic of a system of linear equations with two variables (SPLDV). After the teaching session, a post-test is conducted at the end of each cycle to evaluate the improvement of the student's abilities. The results of the pre and post tests were used to determine the effectiveness of teaching interventions in improving student learning outcomes.

The test is designed to assess the following aspects: reading comprehension, the ability to identify relevant information, and the ability to apply appropriate mathematical strategies to solve word problems. Test scores are used to calculate the percentage of students who achieve the Minimum Completeness Criteria (MCC) of 75, which indicates the level of success in the learning process.

**Observations and Field Notes**

Observations are carried out to monitor the activities of teachers and students during teaching sessions. Observers use structured observation sheets to document teacher and student behavior and engagement. Teacher activities were assessed in terms of teaching clarity, application of the Polya method, and the level of student involvement in lessons. Students' activities were observed to assess how actively they participated in the learning process, how they engaged with the problem word, and how they applied the Polya method in solving problems.

Field notes are also taken during observations to capture additional insights or qualitative data that cannot be measured through structured observations alone. These notes include a description of the student's interaction with the material, their problem-solving approach, and any challenges they encounter during the learning process.

**Documentation**

Documentation includes a collection of relevant teaching materials, such as lesson plans, worksheets, and student work. This provides additional context for observation and allows for a deeper analysis of how the Polya method is applied and how students respond to the lessons. Documentation also serves as a valuable tool to reflect on the teaching process and identify areas for improvement in subsequent cycles.

**Data Analysis Techniques**

The data analysis in this study follows the process of qualitative data analysis, which involves reducing, organizing, and interpreting data systematically. The three main stages of data analysis are: data reduction, data presentation, and conclusion drawn.

**Data Reduction**

The first step in data analysis is to reduce the raw data collected through observations, testing, and field records. This involves selecting relevant data that directly answers the questions and objectives of the research. For example, data from pre- and post-tests are analyzed to determine changes in students' problem-solving abilities. Observational data were screened to focus on key behaviors that showed how well students were able to apply the Polya method in solving word problems.

**Data Presentation**

Once the data is subtracted, they are organized and presented in a meaningful way. This includes the use of tables, charts, and descriptive summaries to highlight key findings. For example, results from pre and post tests are presented in a table that compares the percentage of students who meet MCC in both cycles. Observational data is also presented in a table that summarizes the success rate of both teacher and student activities during each cycle.

**Drawing Conclusions**

Finally, the data were analyzed to draw conclusions about the effectiveness of the Polya method in improving students' problem-solving abilities. Conclusions are based on a comparison of pre- and post-test results, as well as observations and field notes. These findings are then used to inform the planning of the next cycle and to identify areas for improvement in teaching practice.

**Success Criteria**

The success of the study was determined by evaluating the achievement of the Minimum Completeness Criteria (MCC) set at a score of 75 or higher for each student. In Cycle I, the percentage of students who met the MCC was compared to the pre-action data, while in Cycle II, the percentage of

students who met the MCC was expected to show an improvement. In addition to academic success, the study also measured the success of teaching methods by observing the level of teacher and student involvement.

## RESULTS AND DISCUSSION

The results of this study highlight the impact of the Polya Problem Solving Method on students' ability to solve word problems in mathematics. This section presents findings based on data collected through pre- and post-test assessments, observation of student and teacher activities, and field notes. The results of the two cycles of Classroom Action Research (CAR) are discussed in detail, reflecting the improvement of student learning outcomes, teacher performance, and the overall effectiveness of the Polya method in improving students' problem-solving skills.

**Pre-Test Results**

Before the application of the Polya Problem Solving Method, a pre-test was carried out to assess students' initial ability to solve word problems related to the system of linear equations with two variables (SPLDV). The pre-test results showed that the majority of students had difficulty solving word problems, which was consistent with observations made by teachers before the research. The average score for the class was 65.90, with only 12 out of 33 students (36.3%) achieving the Minimum Completeness Criteria (MCC) of 75. These results confirm the need for interventions that will address the challenges students face in understanding and solving word problems. Low completion rates reflect students' limited problem-solving skills, as well as their difficulty in understanding the language and context of the problem.

The pre-test data was used as a baseline to compare student performance after the application of the Polya method. The pre-test findings underscore the importance of finding effective solutions to improve students' problem-solving abilities, especially in relation to word problems in mathematics.

**Results of Cycle I**

Cycle I of Classroom Action Research focuses on introducing the Polya Problem Solving Method to students. The teaching interventions in this cycle aim to improve students' problem-solving skills by guiding them through the four steps outlined by Polya: understanding the problem, drawing up a plan, executing the plan, and evaluating the solution. The goal is to help students develop a systematic approach to solving word problems and improve their critical thinking and problem-solving abilities.

The application of the Polya method in Cycle I resulted in several improvements in students' problem-solving skills. Observation of teacher and student activities shows that the teaching process is interesting and students become more involved in solving problems. However, the results are not entirely satisfactory, as many students still have difficulty implementing the steps of the Polya method effectively. According to the observation sheet, the teacher's activities in Cycle I were assessed at 76%, indicating that the teacher was able to apply the Polya method to a satisfactory level. However, student activities were observed to be less active, with a rating of 64%. This shows that while some students are engaged in the learning process, others are still passive, which hinders their overall progress.

Post-test results for Cycle I showed a moderate improvement in student performance compared to pre-tests. The average score for the class increased to 69.5, and the percentage of students meeting the MCC rose to 63.6%. Although these results show progress, they are still below the target set for this study, which is 75%. The findings from Cycle I reveal that although the Polya method has a positive impact on student learning, there are still some areas that need improvement, especially in ensuring that all students are actively involved in the learning process and are able to fully understand and apply the steps of the Polya method.

Data from Cycle I suggest that the Polya method has the potential to improve students' problem-solving abilities, but further adjustments are needed in Cycle II to improve the effectiveness of the intervention. Based on observations and field records, the researchers identified several key factors that contributed to the limited success of Cycle I. These include the need for more personalized support for struggling students, as well as the need to increase opportunities for active student participation in the learning process.

**Results of Cycle II**

Cycle II of this research aims to overcome the problems identified in Cycle I and further improve students' problem-solving skills using the Polya method. In Cycle II, researchers made several adjustments to teaching strategies, including providing more individualized support to students, increasing opportunities for students to practice problem-solving, and ensuring that all students are actively involved in the learning process. The teacher focuses on providing more detailed explanations and clarifications during the lessons, and students are given more opportunities to work on practice problems both individually and in groups.

Observations of teacher and student activities during Cycle II showed a significant increase. The teacher's activities were assessed at 92%, reflecting the high level of effectiveness in the application of the Polya method. Student activities also showed a noticeable improvement, with a rating of 92%, indicating that students were more engaged and active during the learning process. Researchers noted that students appeared more confident and enthusiastic in solving word problems, and many were able to articulate their reasoning clearly as they worked on the problem.

Post-test results for Cycle II showed a substantial improvement in student performance compared to Cycle I. The average score for the class increased to 78.3, and the percentage of students meeting the MCC rose to 84.84%. This represents a significant improvement in student learning outcomes, suggesting that the adjustments made in Cycle II were effective in addressing the problems identified in Cycle I. Data from Cycle II confirm that the Polya method, when applied with appropriate adjustments and a greater emphasis on student engagement, can be highly effective in improving students' ability to solve word problems.

**Qualitative Data and Student Feedback**

In addition to quantitative data from pre- and post-test tests, qualitative data from student observations and interviews provide valuable insights into the effectiveness of the Polya method. During the observation session, the researcher noted an increase in student participation and engagement in Cycle II compared to Cycle I. Many students were observed asking questions, discussing their problem-solving approaches with their peers, and confidently solving problems on the board.

Student feedback collected through interviews at the end of Cycle II revealed positive responses to the Polya method. Three students with varying levels of ability (high, medium, and low) were interviewed to gather insights into their experiences with the method. All three students stated that they found the Polya method helpful in breaking down complex word problems into more manageable steps. They appreciate the structured approach provided by this method and feel that it makes word problem-solving less intimidating. One student mentioned that they are now more confident in approaching word problems, while another student noted that they find it easier to understand the steps involved in solving the problem after the teacher explains them in detail.

Interviews also highlight that students feel more motivated to participate in the learning process when they are actively involved in problem-solving and discussing their approach with their peers. These findings are consistent with previous research showing that active learning and collaborative problem-solving can significantly improve student engagement and learning outcomes (Seah & Lee, 2020a).

**Comparison of Results Between Cycle I and Cycle II**

The comparison of results between Cycle I and Cycle II clearly shows the positive impact of the Polya Problem Solving Method on students' ability to solve word problems. Table 1 below summarizes the key findings from the pre-test and post-test for both cycles.

**Table 1: Comparison of Pre-Test and Post-Test Results**

| Test | Average score | Percentage of Students Meet MCC |
|---|---|---|
| Pre-Test | 65.90 | 36.3% |
| Cycle I Post-Test | 69.5 | 63.6% |
| Post-Test Cycle II | 78.3 | 84.84% |

As shown in Table 1, there was a clear improvement in both the average score and the percentage of students who met the Minimum Completeness Criteria from Cycle I to Cycle II. The percentage of students who achieved MCC increased from 63.6% in Cycle I to 84.84% in Cycle II, reflecting the effectiveness of adjustments made to teaching methods.

## DISCUSSION

This study aims to examine the effectiveness of the Polya Problem Solving Method in improving students' ability to solve word problems in mathematics. The research was conducted at SMPN 17 Malang, a secondary school in Indonesia, where students were observed struggling with word problems, especially in the context of a linear equation system with two variables (SPLDV). Through the implementation of Classroom Action Research (CAR), this study revealed several significant findings regarding the impact of the Polya method on problem-solving skills, engagement levels, and overall student learning outcomes. This discussion will analyze the findings in relation to the existing literature, provide insights into the successes and challenges faced, and explore their implications for future educational practice.

**Effectiveness of Polya Problem-Solving Methods**

The results of this study show that the Polya Problem Solving Method has a positive impact on students' ability to solve word problems. In Cycle I, the application of the method showed moderate improvement, as evidenced by the increase in average scores from pre-test to post-test and the percentage of students who met the Minimum Completeness Criteria (MCC). The percentage of students who met the MCC increased from 36.3% on the pre-test to 63.6% in Cycle I. This shows that, despite some challenges, the Polya method is effective in improving students' ability to solve word problems to some extent.

However, in Cycle II the full potential of the Polya method became clear. Once adjustments were made to the teaching approach, including providing more individualized support and increasing opportunities for active student participation, the results showed a significant improvement. The average score increased to 78.3, and the percentage of students meeting the MCC rose to 84.84%. These findings are in line with the work of Abdullah et al (2020), who noted that when students follow a structured problem-solving approach like Polya, they are more likely to break complex problems into manageable steps and apply correct mathematical operations. The improvements observed in this study suggest that

the Polya method can effectively improve students' problem-solving abilities, especially when teaching strategies are tailored to meet the specific needs of students.

In accordance with the literature, the success of the Polya method can be attributed to its structured approach, which guides students through the problem-solving process. Polya's four-step method encourages students to focus on understanding problems, drawing up plans, executing plans, and evaluating solutions(Polya, 2014). This step-by-step framework helps students organize their thinking, making it easier for them to solve complex problems. Studies Kaur & Gan (2021a); Seah & Lee (2020b) support this claim, highlighting the effectiveness of the method in improving students' problem-solving and critical thinking skills.

**Student Engagement and Participation**

One of the key observations in the study was a significant increase in student engagement and participation between Cycle I and Cycle II. In Cycle I, while teachers' activities were considered satisfactory (76%), student activities were considered only "quite good" (64%). This shows that even though teachers effectively apply the Polya method, many students are still passive in the learning process. This is in line with previous research by Ratna & Yahya (2022) which showed that a passive learning environment can limit students' ability to fully understand and implement problem-solving strategies.

However, Cycle II showed a marked increase in student engagement, with teacher and student activity rated at 92%. Students were observed to be more active in solving problems, participating in discussions, and seeking clarification when they encountered difficulties. The increase in participation in Cycle II is likely due to several factors, including a more personalized approach adopted by teachers, increased opportunities for students to practice problem-solving, and a more supportive classroom environment. As noted by Tarmizi and Tarmizi (2020), student engagement is essential for effective learning, as it allows students to actively implement the strategies they have learned, leading to better retention and understanding.

The positive changes in student engagement observed in this study support the idea that active learning strategies, such as those used in this study, are more effective than traditional passive methods. The students in Cycle II seem to develop a greater sense of ownership over their learning, which in turn contributes to an increase in their problem-solving abilities. These findings are consistent with research by Seah & Lee (2020b), which highlights the importance of creating interactive learning environments to encourage student participation and improve learning outcomes.

**Personalized Support and Teacher Adaptation**

An important factor contributing to the success of Cycle II is the increased focus on providing personal support to students. Teachers make a concerted effort to engage with students individually, providing assistance to those struggling with certain aspects of the problem-solving process. This approach is especially beneficial for students who have difficulty following the structured steps of Polya's own method. As observed by Muflihah, (2021), personalized support can significantly improve learning outcomes by meeting the individual needs of students, which is especially important in diverse classrooms where students may have varying levels of prior knowledge and problem-solving abilities.

The success of Cycle II also highlights the need for teachers to be flexible and adaptable in their teaching practices. While the Polya method provides a structured framework for solving word problems, it is important for teachers to tailor the method to the specific needs and learning styles of the students. By providing more detailed explanations, encouraging collaborative learning, and offering personalized guidance, teachers can improve the effectiveness of methods. This adaptability is consistent with the findings of Dimyati (2009), who emphasizes the importance of teachers being facilitators who guide

students through the learning process and create an environment that supports active engagement and critical thinking.

**Student Perception and Motivation**

In addition to quantitative and observational data, student feedback from interviews revealed that students had positive perceptions of Polya's method and its impact on their learning. Interviews show that students feel more confident in solving word problems after using the Polya method. This is in line with the findings of Wulandari et al (2021), who noted that structured problem-solving methods can increase students' confidence by providing them with a clear and systematic approach to solving complex problems. Furthermore, students state that this method helps them relate mathematical concepts to real-world situations, making the problem more meaningful and interesting.

Positive student feedback also shows that Polya's method increases their motivation to engage with math. By breaking down complex problems into smaller, more manageable steps, this method reduces student anxiety and makes problem-solving feel more achievable. This is in line with the research of Sumarwan & Pradipta (2020), who found that when students are able to understand the problem-solving process and see the tangible results of their efforts, their motivation and engagement levels increase significantly.

**Challenges and Limitations**

While the findings from Cycle II are very positive, the study also faces several challenges that need to be addressed in future research. One of the main limitations is the variability of prior knowledge and students' mathematical abilities. As observed in Cycle I, some students struggle to understand the basic concepts involved in solving word problems, which hinders their ability to fully benefit from the Polya method. In future studies, it may be helpful to implement additional preparatory activities to ensure that all students have a solid foundation in key math concepts before engaging with problem-solving strategies.

Another challenge is the limited time available for the implementation of the Polya method. As mentioned in the results section, time constraints in Cycle I make it difficult for some students to fully engage with the method and practice its application. In future studies, extending the duration of interventions or including more practice sessions may further improve student outcomes.

**Conclusions and Implications for Future Practice**

This study provides strong evidence of the effectiveness of the Polya Problem Solving Method in improving students' ability to solve word problems in mathematics. The findings suggest that with proper adjustments to teaching strategies, including personalized support, active learning, and increased student engagement, the Polya method can significantly improve students' problem-solving skills. The study also highlights the importance of flexibility and teacher adaptation to meet the diverse needs of students. Based on the results, it is recommended that teachers consider incorporating structured problem-solving methods such as Polya into their teaching practices, especially in secondary education settings where students often face challenges with word problems. Future research should focus on refining the application of the Polya method, exploring its use in different mathematical contexts, and addressing challenges related to student time and readiness.

**Conclusion**

This study shows the effectiveness of the Polya Problem Solving Method in improving students' ability to solve word problems in mathematics. The results showed a significant improvement in student engagement and performance after the implementation of the method, with a significant increase in the percentage of students meeting the Minimum Completeness Criteria (MCC) from Cycle I to Cycle II. These findings suggest that structured problem-solving methods, when tailored to meet students' needs, can be highly effective in improving critical thinking and math skills.

This research contributes to the existing body of knowledge by providing empirical evidence on the positive impact of the Polya method in the secondary education environment, especially in Indonesia. It supports previous research on the benefits of active learning and problem-solving frameworks, highlighting the importance of teacher flexibility and student engagement. However, the study also identified some challenges, such as different levels of prior knowledge among students and time constraints, that could be addressed in future research. Further exploration of the Polya method in different mathematical contexts and educational settings will provide valuable insights into its wider application. Additionally, investigating the long-term effects of such methods on students' problem-solving abilities and academic performance can offer a deeper understanding of their benefits.

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