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Use of Real Problem to Strengthen Mathematical Thinking Skills in Learning

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ABSTRACT: *The aim of this study is to assess the effectiveness of incorporating real-world problems in enhancing students' problem-solving skills in mathematics. The study employs a quasi-experimental design with pre- and post-test control groups. Two eighth-grade classes serve as the sample, with the experimental group applying a real-world problem-solving method and the control group using traditional teaching methods. Problem-solving skills are assessed based on specific patterns of performance. The results revealed that the experimental group, with an average score of 75,68, outperformed the control group, which scored 68,32, with a statistically significant difference ($F=9.72$, $p < 0.05$). The study confirms that integrating real problems into learning leads to more consistent outcomes and helps enhance students' critical, analytical, and collaborative thinking. Through active involvement in exploration and discussions, students develop a deeper understanding and better ability to apply mathematical concepts to real-life situations. The study recommends expanding the use of real problems in mathematics instruction, supported by teacher training and adequate resources, to maximize learning effectiveness and help students acquire skills applicable to contemporary challenges.*

KEYWORDS *-Real, Problems, Strengthen, Mathematical, Thinking, Learning*

I. INTRODUCTION

Education serves to prepare people to face obstacles in the future. Successors face a more complex world. One of the skills that students need to have is expertise in solving problems, especially in the context of mathematics learning [1]. Mathematics not only focuses on mastering calculations, but also serves to train logical thinking patterns and analytical skills that are very useful in daily life [2]. Despite this, many students still have difficulty understanding and applying mathematical concepts to real problems [3]. This indicates the need to use a more innovative and student-oriented approach to learning to improve their understanding [3]. One approach that can be used for this purpose is a real problem [4].

As a first step, Problem-based learning is an approach that emphasizes problem-solving skills. In this approach, students are faced with relevant and complex problems, which encourages them to think critically, seek information, and work together in groups [5]. It does not allow students to understand the theory, but also to implement their knowledge to real situations [6]. In contrast to the traditional learning approach that focuses on the role of the teacher, it gives students greater freedom to direct their own learning process [7]. This approach makes students more active and responsible for their learning, so that real problems are considered effective in developing skills in solving problems, especially in mathematics lessons [8]. The application of real problems in mathematics has many advantages, one of which is the ability to develop higher-order thinking skills [9].

In mathematics learning, students often face problems that require the ability to analyze, evaluate, and synthesize. These three components are essential to improve their critical analysis capabilities [10]. In addition, real problems also contribute to the development of students' skills. communication and cooperation, because problem solving is usually done in groups [11]. Thus, real problems not only prepare students to face academic exams, but also to solve real-life challenges [12]. This approach is in line with the goal of 21st century education, which is to produce individuals who are not only academically superior, but also adaptive, creative, and ready for change.

However, the implementation of real problems in mathematics learning requires careful planning and implementation in order to run effectively. Teachers must be able to design challenging problems but still according to the level of student understanding [13]. In addition, teachers also have an important role as facilitators who support students in exploring their ideas to find solutions [14]. This process requires a paradigm shift in learning, from a teacher-dominated approach to student-centered learning [15]. Therefore, research on the effectiveness of real problems in improving students' problem-solving skills is important to do [16]. With a deeper understanding of the benefits and challenges of real problems, it is hoped that this method can be implemented more widely and effectively in mathematics learning.

Although many studies have shown the effectiveness of real problems in learning, the implementation of this method in mathematics still faces a number of obstacles. One of the main obstacles is the lack of understanding of teachers on how to design problems in accordance with the principles of real problems [17]. Many teachers are so used to traditional learning methods that it is difficult to integrate real problems into the curriculum [18]. In addition, limited resources and time in the learning process are also a significant challenge [19]. This results in the implementation of real problems that are not optimal, especially at the secondary school level [4]. Thus, further studies are needed on how real problem methods can be applied effectively in mathematics learning.

In addition to implementation constraints, there are also gaps in research related to the effectiveness of real problems on various aspects of student skills. Most of the research focuses more on academic outcomes or conceptual understanding, while aspects of students' problem-solving skills are still underpaid [20]. In fact, problem-solving skills are at the core of the real problem-solving approach itself [21]. Existing research is often only descriptive without examining in depth the process of developing [22]. Therefore, more exploratory and focused research is needed on how real problems can improve problem-solving skills in the context of mathematics learning [21], [23].

On the other hand, the application of real problems is often limited to specific contexts, such as schools with adequate facilities and highly motivated students. This creates a gap between theory and practice, especially in schools with limited resources. Not all students have the same initial ability to engage in the problem-based learning process [21], [24]. Learning environment factors, such as the availability of learning aids and teacher support, also affect the successful implementation of this method [25]. As a result, research that examines the application of real problems in various social and economic contexts is indispensable to obtain a more comprehensive picture.

In addition, there are still few studies that discuss the role of teachers as facilitators in the application of real problems, especially in mathematics subjects. The role of teachers is crucial in helping students understand problems, direct discussions, and ensure the learning process stays focused [26]. However, many teachers have not received adequate training to carry out this role effectively [16], [18]. This causes students not to get an optimal learning experience through real problems [27], [28]. By identifying and addressing these gaps, research is expected to provide practical recommendations to improve teachers' skills in supporting the success of real problems [29].

This research is expected to be able to provide a broader understanding of the application of real problems in mathematics teaching, especially to develop students' problem-solving skills. The results of this study can help educators in designing more innovative learning approaches that suit the needs of students, so that the learning process becomes more efficient and relevant [30]. In addition, this research also has the potential to identify obstacles that arise in the implementation of real problems and offer practical solutions to overcome these challenges in various educational settings [31]. Thus, this research can be a guide for education policymakers in integrating real problems into the school curriculum to improve the quality of learning [32]. Furthermore, this research is expected to increase teachers' understanding of their role as facilitators in real problems so that it can support a more active and collaborative learning process [33]. In addition, it contributes to the educational literature, especially in explaining the relationship between real problems and the development of students' problem-solving skills in the field of mathematics [34].

The purpose of the study is to analyze the effectiveness of real problem-based learning methods in improving students' skills in solving mathematical problems. In addition, to analyze the factors that affect the success rate [35]. implementation of real problems, such as the role of teachers, the availability of resources, and the socio-economic background of the school [4].

Another goal is to consider how the process of applying real problems plays a role in strengthening students' critical, analytical, and collaborative thinking skills when solving math problems. This research also aims to explore the obstacles faced by teachers when implementing real problems in the classroom and provide recommendations to overcome these obstacles. In addition, this research aims to provide practical guidance to teachers to design questions that are in line with the principles of real problems and the level of student understanding. Ultimately, this research is expected to produce evidence-based suggestions to support the development of teacher training programs to improve their skills as facilitators in problem-based learning.

II. METHOD

This study uses a quasi-experimental method with a Pretest-Posttest Control Group Design. According to Fraenkel and Wallen, the quasi-experimental method allows research to be conducted on naturally formed groups without using random sampling techniques [36], [37]. This makes this method suitable for research contexts in formal education settings, where the grouping of students in classes is predetermined by the school institution.

The population in this study is all grade VIII students in one of the junior high schools in City X. The research sample was selected by purposive sampling technique, where two classes with similar characteristics were used as research subjects. Class VIII A was chosen as an experimental group given Problem-Based Learning, while class VIII B functioned as a control group using traditional teaching methods.

The research procedure is carried out in several stages, namely: Pretest: Before being given treatment, both groups are given a preliminary test to measure their initial ability in solving mathematical problems. Treatment: The experimental group gets problem-based learning during the research period, while the control group stays with traditional learning methods. Posttest: After the treatment is complete, both groups are again given a test to measure changes in their ability to solve math problems.

The instrument used in this study is a test of mathematical problem-solving ability given before and after the treatment. This test is developed based on problem-solving indicators which include problem understanding, solution planning, strategy implementation, and re-checking answers.

The data obtained were analyzed using descriptive and inferential statistics. Descriptive analysis was carried out to describe the distribution of mean scores, standard deviations, and the difference in the increase in pretest and posttest scores between the experimental and control groups. The results of the analysis showed that the average score of mathematical problem-solving ability in the experimental group (75,68) was higher than that of the control group (68,32). In addition, the standard deviation of the experimental group (8,42) was smaller than that of the control group (7,85), which indicated that the results of problem-based learning were more consistent in improving students' problem-solving skills.

In addition, the t-test was used to determine the significance of the difference between the experimental group and the control group. Thus, this study not only identifies an increase in mathematical problem-solving skills, but also tests the effectiveness of the implementation of problem-based learning statistically.

III. RESULT

The descriptive analysis revealed notable differences in problem-solving abilities between the experimental and control groups. Students in the experimental group, who were taught using problem-based learning methods, achieved an average score of 75,68, whereas those in the control group, who experienced traditional learning methods, only reached an average of 68,32. This significant difference suggests that problem-based learning has a more positive impact on students' ability to solve problems effectively. By engaging students in real-world scenarios and encouraging active problem-solving, this method fosters deeper understanding and analytical thinking, which traditional methods may not fully support.

Additionally, the standard deviation values indicate that the experimental group demonstrated more stable achievement in problem-solving skills, with a recorded standard deviation of 8,42 compared to 7,85 in the control group. The relatively lower variation in scores within the experimental group suggests that problem-based learning not only improves problem-solving abilities but also ensures more consistent performance among students. This stability may be attributed to the structured yet flexible nature of problem-based learning, where students collaboratively explore solutions and receive guidance throughout the process. Therefore, these findings reinforce the effectiveness of problem-based learning in enhancing students' problem-solving skills while also maintaining a more uniform learning outcome across different students.

The results of comparison of problem-solving scores across groups test indicate that the class factor, which differentiates the experimental and control groups, has a significant impact on students' problem-solving abilities. With an F-value of 9,72 and a p-value of 0,003, the findings suggest that the teaching approach used in the experimental group—likely problem-based learning—contributed to higher problem-solving performance compared to the traditional methods employed in the control group. This result reinforces the effectiveness of innovative instructional strategies in enhancing students' analytical skills and underscores the importance of implementing engaging learning approaches to improve overall problem-solving abilities.

Furthermore, the Mathematics Initial Ability Factor (MIAF) also demonstrated a significant influence on problem-solving performance, as indicated by an F-value of 10,31 and a p-value of 0,000. This finding suggests that students' prior mathematical knowledge plays a crucial role in determining their success in solving problems, highlighting the need for differentiated instruction that accommodates varying levels of mathematical proficiency. However, the interaction effect between class and MIAF was not significant ($F = 1.51$, $p = 0.230$), implying that the impact of teaching methods on problem-solving skills does not vary significantly based on students' initial mathematical ability. This suggests that while both teaching methods and prior knowledge independently influence problem-solving ability, their combined effect does not create additional advantages or disadvantages in learning outcomes.

The ANOVA results for the problem-solving study demonstrate that implementing problem-based learning significantly enhances students' problem-solving abilities. This improvement is attributed to the opportunities students receive to engage in in-depth exploration and analysis of problems that are closely related to their daily lives. Unlike traditional teaching methods that focus primarily on procedural knowledge, PBL encourages students to actively construct their understanding by investigating real-world problems. This approach fosters critical thinking, as students must analyze various aspects of a problem, identify relevant mathematical concepts, and develop appropriate solutions.

Moreover, problem-based learning not only strengthens students' conceptual understanding but also equips them with the ability to apply mathematical principles in practical contexts. Through structured problem-solving processes, students learn to approach challenges logically, organize their thoughts systematically, and justify their solutions effectively. This hands-on experience helps bridge the gap between theoretical knowledge and real-world application, making learning more meaningful and engaging. As a result, students develop greater confidence in tackling complex problems, preparing them for future academic and professional challenges that require strong analytical and reasoning skills.

Furthermore, problem-based learning fosters an active learning environment where students take ownership of their learning process. By engaging in discussions, exploring multiple solution pathways, and working collaboratively with peers, students develop a deeper understanding of mathematical concepts. This interactive approach encourages them to think critically, evaluate different perspectives, and refine their reasoning skills. Rather than passively receiving information, students become active participants who construct knowledge through meaningful dialogue and hands-on problem-solving, making the learning experience more dynamic and impactful.

In addition to enhancing problem-solving abilities, PBL also plays a crucial role in developing students' social and communication skills. The collaborative nature of this method encourages students to articulate their thoughts clearly, listen to others' viewpoints, and work together to reach consensus. Through these interactions, they gain confidence in expressing their ideas and defending their reasoning, which contributes to their overall self-assurance. Moreover, the ability to navigate group discussions and contribute constructively to team-based problem-solving prepares students for real-world scenarios where effective communication and teamwork are essential for success.

The influence of early mathematical ability on student learning outcomes is significant, as students with stronger foundational knowledge tend to achieve better results in problem-solving tasks. A solid grasp of basic mathematical concepts allows these students to process information more efficiently, recognize patterns, and apply appropriate strategies when tackling complex problems. This finding highlights the importance of strengthening students' fundamental skills from an early stage, as a well-developed mathematical foundation serves as a crucial stepping stone for more advanced learning. Teachers should, therefore, implement strategies that reinforce core mathematical competencies, ensuring that all students, regardless of their initial skill levels, are equipped with the necessary tools for success.

However, the study also reveals that problem-based learning benefits students across all ability levels, including those with low or moderate prior knowledge. Unlike traditional instructional methods that often favor high-achieving students, PBL provides an inclusive learning environment where all learners can actively engage in meaningful problem-solving. Through exploration, collaboration, and guided discovery, students with varying levels of ability can develop their mathematical reasoning and critical thinking skills at their own pace. This adaptability makes PBL an effective approach for addressing diverse classroom needs, fostering equity in learning outcomes, and ensuring that every student has the opportunity to improve their problem-solving abilities.

In essence, the effectiveness of problem-based learning extends across diverse groups of students in heterogeneous classrooms, demonstrating its versatility in meeting the needs of learners with different backgrounds and abilities. Whether students have advanced, average, or lower mathematical skills, PBL creates an engaging environment that encourages active participation, critical thinking, and problem-solving. This inclusive approach ensures that all students, regardless of their prior knowledge or learning style, can benefit from the method's hands-on and collaborative nature. As a result, PBL supports the development of key cognitive skills in students, empowering them to engage with challenging tasks and gain confidence in their abilities.

Moreover, the findings of this study align with previous research that highlights the success of real-world problems in fostering critical thinking, analytical skills, and the ability to adapt to complex situations. By immersing students in relevant and thought-provoking problem contexts, PBL promotes deeper learning and helps students understand the real-world applications of mathematical concepts. This approach encourages students to take ownership of their learning process, actively participating in discussions, exploring various solutions, and reflecting on their progress. As students tackle real problems, they come to recognize the significance of mathematics not only as an academic subject but also as a valuable tool for addressing everyday challenges, thereby reinforcing the practical relevance of mathematical knowledge in their lives.

IV. DISCUSSION

One possible solution to overcoming the limited application of real problems in diverse educational contexts is to develop adaptable problem-solving approaches that cater to varying levels of resources and student motivation. Teachers can design real-world problems that do not require advanced facilities but instead rely on everyday experiences and locally available materials [38], [39]. For instance, mathematical modeling activities can incorporate familiar objects, cultural artifacts, or community-based scenarios, making them more accessible to students in under-resourced schools [40]. Additionally, integrating technology, such as mobile applications or online collaborative platforms, can help bridge the gap by providing interactive problem-solving experiences without the need for expensive infrastructure [41].

Another effective approach is fostering intrinsic motivation and problem-solving skills among students, regardless of their background. Educators can achieve this by implementing engaging instructional strategies such as project-based learning, inquiry-based learning, and peer collaboration, which encourage students to take ownership of their learning [13], [42] Providing real-world problems that connect with students' interests, cultural contexts, and future aspirations can enhance their engagement and persistence in problem-solving tasks [5], [43] Furthermore, teacher training programs should emphasize strategies for adapting real-world problem applications to diverse classroom settings, ensuring that all students have equitable access to meaningful learning experiences [14].

To address the limitation of real-world problem applications being confined to well-equipped schools with highly motivated students, educators can adopt a differentiated instructional approach that accommodates diverse learning environments. One strategy is to simplify complex real-world problems by relating them to students' immediate surroundings and daily experiences [44], [45]. For example, teachers in resource-limited schools can use locally available materials, such as household items or community-based scenarios, to create engaging mathematical or scientific problems [21], [46], [47] Additionally, educators can leverage storytelling and case studies that reflect students' cultural and socioeconomic backgrounds, making real-world problems more relatable and meaningful [48], [49]. By contextualizing problems in familiar settings, students from various backgrounds can develop problem-solving skills without requiring extensive resources [50].

Another effective solution is to incorporate collaborative learning and community partnerships to expand access to real-world problem-solving experiences. Schools can establish partnerships with local businesses, universities, or organizations to provide students with hands-on projects and real-world challenges that do not rely solely on school facilities. Virtual learning tools, such as online discussion forums and interactive simulations, can also help bridge the gap for schools with limited physical resources [51]. Moreover, fostering a growth mindset among students—where effort and perseverance are emphasized over innate ability—can enhance motivation and engagement, even among those who may initially struggle with problem-solving [25], [52], [53]. By creating an inclusive and resourceful learning environment, educators can ensure that real-world problem-solving is accessible to all students, regardless of their school's infrastructure or initial level of motivation [54], [55].

To address the lack of studies on teachers as facilitators in applying real-world problems in mathematics, more research should be conducted on effective facilitation strategies in various classroom settings. Studies should focus on how teachers guide students through problem-solving processes, encourage critical thinking, and adapt problems to different student abilities [56]. Action research and case studies in diverse educational contexts can provide valuable insights into best practices for facilitation [57]. Additionally, professional development programs should emphasize the role of teachers in structuring discussions, asking guiding questions, and fostering student engagement in real-world problem-solving [2], [58]. By equipping teachers with research-based facilitation techniques, they can better support students in understanding and solving complex mathematical problems [59].

Another solution is to integrate facilitation training into teacher education and continuous professional development programs. Pre-service and in-service teachers should receive training on how to effectively introduce, scaffold, and assess real-world problem-solving activities [60]. Workshops, peer observations, and collaborative lesson planning can help teachers refine their facilitation skills and learn from successful classroom practices [61]. Furthermore, developing digital resources, such as instructional videos, online courses, and teaching guides, can provide teachers with ongoing support in implementing real-world problems [6], [24]. By strengthening teachers' roles as facilitators, students can receive the necessary guidance to explore, discuss, and solve mathematical problems in meaningful and engaging ways [62].

To achieve a broader understanding of the application of real-world problems in mathematics teaching, further research should focus on diverse educational settings, including schools with varying levels of resources and student abilities [63]. Comparative studies can examine how different instructional strategies, such as inquiry-based learning, project-based learning, and problem-based learning, impact students' problem-solving skills [20]. Additionally, longitudinal studies can track students' progress over time, providing insights into the long-term effectiveness of real-world problem applications [4], [64]. By collecting and analyzing data from various contexts, researchers can develop more comprehensive models for integrating real problems into mathematics teaching, ensuring that the approach is adaptable and beneficial for all students [65].

Another essential step is to bridge the gap between research and classroom practice by developing practical teaching frameworks based on research findings. Educators should have access to well-structured lesson plans, teaching modules, and digital resources that demonstrate how real-world problems can be effectively applied in mathematics classrooms [66]. Teacher training programs and workshops should also be designed to equip teachers with the skills to implement research-based strategies [67]. Moreover, collaboration between researchers, educators, and policymakers can help translate research insights into educational policies that support problem-solving-based mathematics instruction [43], [68] By making research findings more accessible and applicable, mathematics education can be enriched with meaningful problem-solving experiences that enhance students' critical thinking and analytical abilities [69].

V. FIGURES

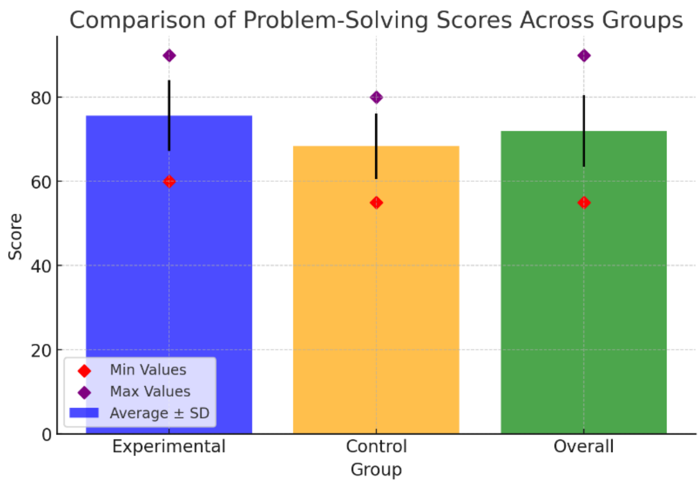

Fig 1. Comparison of Problem-Solving Scores Across Groups

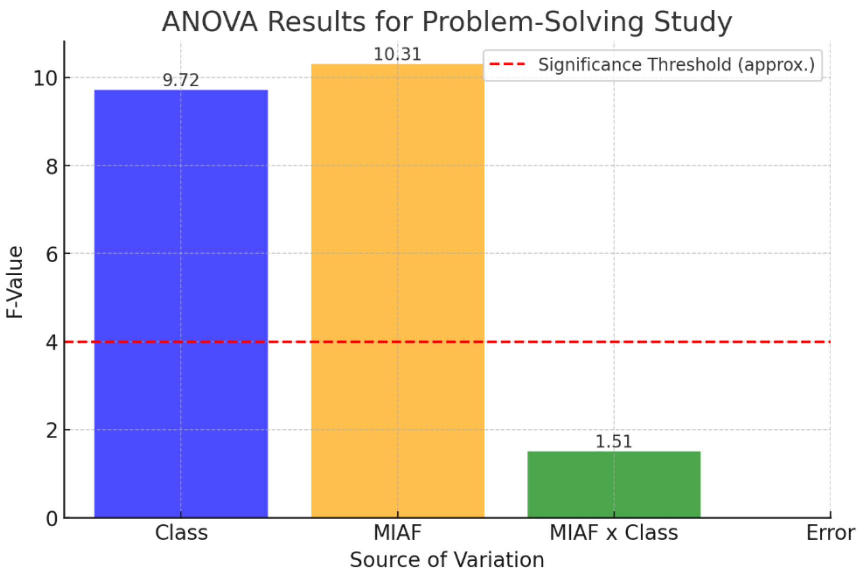

Fig 2. ANOVA Results for Problem Solving Study

VI. CONCLUSION

This study revealed very interesting results related to the application of problem-based learning methods in mathematics learning. At first, students in the experimental class who applied real problems showed varying performance, but overall, the average score of their problem-solving ability was superior to that of students in the control group who applied conventional methods. This indicates significant progress in the problem-solving skills of students who are actively involved in the real problem process. In addition, more consistent learning is reflected in the smaller standard deviations in the experimental group, which suggests that real problems can provide more stable and measurable results.

The application of real problems not only focuses on improving academic ability, but also sharpens students to think critically, discuss, and collaborate in groups. Through these activities, their social skills also improve, showing that real problems provide far-reaching benefits. In fact, these findings show that the real problem method is effective at all levels of students' mathematical abilities whether they have large, medium, or small starting abilities. In this way, real problems not only improve students' problem-solving abilities, but also prepare them to face real challenges in daily life, developing better analytical and logical thinking skills.

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