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Enhancing Students' Mathematical Problem-Solving Skills through the Implementation of the Project-Based Learning (PjBL) Approach

Alifah Shofia Fuadah[1], Achmad Firmansyah[2]*
[1,2]Department of Mathematics Education, UIN Maulana Malik Ibrahim, Malang, Indonesia
*Correspondence: achmadfirmansyah504@gmail.com

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Abstract

This study aims to improve students' mathematical problem-solving skills through a Project-Based Learning (PjBL) approach. The type of research used is classroom action research, conducted at MAN Kota Blitar. The subjects of this study were 32 students of class X MIPA 1, while the object of the study was the implementation of the Project-Based Learning approach in relation to students' mathematical problem-solving abilities. The instrument used in this research was a test. The results of the study indicate that the implementation of the Project-Based Learning (PjBL) approach in class X MIPA 1 at MAN Kota Blitar successfully enhanced students' problem-solving skills in trigonometry. This was evident from the improvement in students' learning evaluation results, particularly in their mathematical problem-solving abilities. In the first cycle, 14 students (44%) demonstrated good problem-solving skills, while in the second cycle, the number increased to 26 students (81%). Thus, there was a 37% increase in the percentage of students with good mathematical problem-solving skills between the first and second cycles.

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Introduction

Problem-solving ability is one of the essential skills in the 21st century. This skill involves the ability to understand and analyze situations with the goal of finding the best possible solution. Moreover, problem-solving reflects a person's capacity to formulate new and effective responses to produce appropriate solutions (Stephen et al., 2017). It is categorized as a high-order thinking skill that is crucial to be developed among students (Ripai & Sutarna, 2019)

Problem-solving ability is one of the core competencies expected to be achieved in mathematics learning, as stated in Regulation of the Minister of Education and Culture (Permendikbud) No. 21 of 2016 concerning the Content Standards for Primary and Secondary Education (Kristiyanto, 2020). This competency is highly important because it not only helps students grasp mathematical concepts but also provides practical skills to address various real-life issues. Furthermore, it plays a vital role in preparing students to face challenges in the future workforce, where critical and creative thinking abilities are increasingly demanded.

The process of mathematical problem-solving involves structured stages of high-order thinking, beginning with understanding the problem, planning a solution, implementing the plan, and evaluating each step taken. According to Astutiani et al. (2019), these stages require logical and systematic thinking skills, including activities such as visualization, association, abstraction, manipulation, reasoning, analysis, synthesis, and generalization. Each step must be carried out carefully and interconnectedly to ensure the solution fits the given problem.

However, obtaining the correct solution is not an easy task. Nurfitriyanti (2016) Nurfitriyanti (2016) emphasizes the importance of practice and teacher guidance to help students effectively master problem-solving skills. Teachers play a strategic role in providing structured exercises that are tailored to students' needs, enabling them to better understand patterns of problem-solving. With the right approach, students will not only be able to solve mathematical problems correctly but also develop critical thinking skills that are beneficial in many areas of their lives.

Observations conducted in a class at MAN Kota Blitar revealed that students were studying trigonometry. It was found that several students struggled to solve word problems as they tended to answer immediately without following the systematic steps of problem-solving. They often neglected the stages of understanding the problem, planning a solution, executing the plan, and evaluating it—leading to a lack of accuracy and increased risk of errors in finding solutions.

One innovative approach that offers various advantages is the implementation of the Project-Based Learning (PjBL) model (Anggraini & Wulandari, 2020). PjBL has the potential to enhance learning motivation, student engagement, and various skill areas. In addition, this method promotes communication skills through cooperative group work and allows students to manage their own projects. Thus, it is expected that students will gain a deeper understanding of the material and be able to apply the concepts they have learned to real-life situations (Wahyu, 2016).

Project-Based Learning also presents opportunities for teachers to manage classroom learning by incorporating projects as part of the learning process (Damayanti, 2023). Through this approach, students' creativity and motivation can be fostered. According to Wahyu (2016), PjBL focuses on core curriculum, supporting students in inquiry, problem-solving, and task execution using a student-centered approach. Moreover, this model encourages students to produce tangible products. Using PjBL, students become more actively involved in the learning process, while the teacher acts as a facilitator and evaluator of the students' project outcomes.

PjBL is a learning model that requires a relatively long period of time because it focuses on student activities in understanding concepts or principles through inquiry and problem-solving (Gultom et al., 2022; Wati & Sahronih, 2022). In this model, students investigate meaningful problems and apply their findings in a project, resulting in valuable learning experiences and the construction of their own knowledge. This approach emphasizes student activities in seeking solutions through exploring, examining, building, and presenting products based on real-life experiences. PjBL allows students to work individually or in teams to create meaningful projects.

Each learning model has its own advantages, and Project-Based Learning offers numerous benefits. PjBL can increase students' learning interest, enhance problem-solving skills, and encourage students to be more diligent in facing challenges. Additionally, PjBL fosters collaboration among students, motivates them to build and practice communication skills, and sharpens their ability to process learning materials. This model also allows students to share knowledge and apply concepts in real projects, creating an enjoyable learning atmosphere for both students and teachers (Nurmawati et al., 2024).

Based on the explanation above, this study focuses on the implementation of the PjBL approach to improve mathematical problem-solving skills. This ability is essential because it requires students to find effective solutions to complex problems. Therefore, this research is titled: "Enhancing Students' Mathematical Problem-Solving Skills through the Implementation of the Project-Based Learning (PjBL) Approach."

Methods

This study is categorized as classroom action research (CAR). The research was conducted at MAN Kota Blitar with the subjects being students of Grade X MIPA 1 during the even semester. Classroom action research is a class-based research approach aimed at addressing teachers' problems, particularly in improving the quality and outcomes of learning, as well as experimenting with new approaches to maximize the effectiveness of the teaching process.

This study involved 32 students from Grade X MIPA 1 at MAN Kota Blitar as the research subjects. The object of the study was the implementation of the Project-Based Learning (PjBL) approach in relation to students' mathematical problem-solving abilities. The research was carried out in two cycles, with each cycle consisting of one meeting. Each cycle comprised four stages: planning, implementation, observation, and reflection, following the model developed by Kemmis & McTaggart.

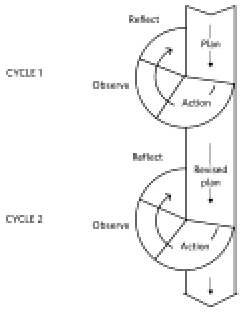

Figure 1. Kemmis and Mc Taggart Model.

In the first stage, planning, activities included preparing lesson plans and fulfilling instructional needs. The implementation stage took place during the actual learning process. Next, during the observation stage, student activities during the learning process were observed and recorded. These observations were documented for further analysis after the completion of the research. The final stage was reflection, conducted after the lesson. In this stage, the researcher and the observer discussed the observation results. The purpose of the reflection stage was to evaluate the learning process and identify the strengths and weaknesses of each completed cycle.

To measure students' problem-solving skills, a test instrument was used. This test consisted of several questions requiring responses or solutions to assess specific levels of ability or aspects of the students (testees). As testees, the students of Grade X MIPA 1 at MAN Kota Blitar played a role in this research, and the tests were administered at the end of each cycle. The test instrument was an evaluation task in the form of word problems focused on the topic of trigonometry

Result and Discussion

The research was conducted at MAN Kota Blitar, involving 32 students from Grade X MIPA 1 as the research subjects. Data collection was carried out through the teaching and learning process, which consisted of several cyclical stages, based on the classroom action research model by Kemmis & McTaggart, comprising plan, action, observe, and reflect (Maliasih et al., 2017). This classroom action research (CAR) was conducted in two cycles, which are described as follows:

Cycle I

Based on the research design, the learning activities in the first cycle were conducted in a single meeting with Grade X MIPA 1 students at MAN Kota Blitar. As part of Cycle I, the four stages of classroom action research were implemented: plan, action, observe, and reflect (Widayati, 2008).

Plan

To ensure the learning activities aligned with the research objectives, the researcher prepared several key components during this initial stage. The planning involved explaining the what, why, where, when, and *how* (Handayani et al., 2022). The following were the preliminary activities conducted during the planning stage:

a. Developing a teaching module as a guide for instructional activities
b. Preparing the learning materials to be discussed
c. Creating and providing observation sheets
d. Preparing data collection instruments, such as evaluation questions

During the core learning activity in the single meeting of Cycle I, the teacher provided an explanation of the lesson material while students listened attentively. Afterward, students were given evaluation questions as a form of problem-solving exercise to assess their mathematical problem-solving skills. The material covered during this activity was trigonometry, as outlined in the teaching module. In addition, observation sheets were prepared by the teacher to assess the implementation of the learning process and to monitor student activities during the lesson.

Action

In the second stage, namely the action, the teacher implemented the instructional activities based on the lesson plan outlined in the teaching module. The learning process was carried out in a typical classroom setting, beginning with the opening, followed by the main activity, and ending with the closing.

The opening phase began with the teacher greeting the students, leading a prayer together before the lesson started, checking student attendance, and providing an introduction and motivational encouragement to prepare the students for learning. The main activity involved the delivery of the trigonometry material by the teacher to the students. Using a combination of lecture and question-and-answer methods, the teacher explained the content clearly. Students were asked to pay attention and were encouraged to ask questions if they encountered any difficulties. The teacher responded to student questions and elaborated further as needed.

Following the explanation, the teacher presented several example problems for the students to solve. The teacher demonstrated the problem-solving steps and provided clear examples of how to approach and solve such problems. Students were then given the opportunity to attempt solving word problems using the steps previously demonstrated by the teacher. Additional time was given for questions and clarification if students encountered further difficulties.

At the end of the lesson, the teacher assessed the students' problem-solving abilities by administering evaluation questions related to the trigonometry material. These evaluation questions were presented in the form of word problems. After completing the sequence of learning activities, the teacher concluded the lesson by summarizing the key points, followed by a closing prayer and farewell.

Observe

The third stage of this research was the observe, which was conducted concurrently with the implementation stage. During the teaching and learning process, the teacher observed both the implementation of the learning activities and student behavior in the classroom (Primandani, 2010). This observation aimed to assess students' mathematical problem-solving skills using the lecture and question-and-answer methods.

Observations were made using an observation sheet that had been prepared beforehand. The observation sheet included several key aspects, such as the process of action, outcomes of the action, the conditions under which the action was implemented, and challenges that arose during instruction. This provided a clear picture of the effectiveness of the applied method in improving students' problem-solving skills.

The main goal of this observation stage was to evaluate student engagement in solving the given problems and to assess how well the implementation aligned with the planned actions. Through this process, the teacher was able to identify the strengths and weaknesses of the applied instructional method and determine what adjustments or improvements might be necessary for the next cycle.

Reflecting Stage

The final stage in this cycle was the reflecting stage, which took place after the instructional session was completed. In this phase, the researcher analyzed data gathered from prior observations, including the implementation of teaching activities, problem-solving tasks, and field notes. The goal of the reflection was to identify barriers and difficulties encountered during the teaching process in order to evaluate and determine appropriate solutions. The teacher reflected on the students' mathematical problem-solving abilities based on the observation sheets prepared earlier.

Overall, the implementation of Cycle I followed the planned procedures; however, some challenges arose—such as students' slow progress due to difficulties in understanding the material or lack of motivation, which impacted the effective use of time. The exercises provided during the session served to assess students' comprehension of the subject matter and to measure their problem-solving capabilities.

Based on the results of the reflection, several improvements were proposed for the next cycle:

a. Additional practice problems are necessary to deepen students' understanding of mathematical concepts.
b. Student-centered learning strategies need to be adopted to increase active participation and comprehension.
c. Students should be trained to identify given information, plan and solve problems systematically, and interpret the solutions.
d. Students should be reminded by the teacher to recheck their answers.

Cycle II

The design of the second cycle followed the same phases as in the first cycle, which were conducted in one meeting. The difference in Cycle II lay in the adjustments made based on the evaluation of Cycle I results, including solutions to address the challenges encountered during the learning process. The stages of Cycle II also followed the plan, action, observe, and reflect model.

Plan (Cycle II)

Based on the reflections from Cycle I, a new learning plan was developed for Cycle II. The learning in Cycle II adopted a cooperative approach through the implementation of Project-Based Learning (PjBL). Students were divided into small groups consisting of 4–5 members. In general, the planning activities in Cycle II were similar to those in Cycle I (Dinata & Hodiyanto, 2022). However, based on the results of Cycle I reflections, several enhancements were included to improve the effectiveness of instruction:

a. The teacher applied a cooperative learning model using a project-based learning approach.

b. Students were allowed to independently explore the material, engage in group discussions, and present the outcomes to the class.
c. Students were asked to find problem examples and their solutions and present them.
d. Students were encouraged by the teacher to participate actively in group discussions.
e. Additional time was allocated for solving problems, allowing students to analyze problems more thoroughly.
f. Students were reminded to check their answers carefully.

Action (Cycle II)

In accordance with the reflection from Cycle I, the teacher implemented the learning activities as planned in Cycle II. After the opening session, the teacher explained the objectives and structure of the lesson to the students. Then, the students were grouped into teams of 4–5 members to work on a project involving the exploration of trigonometric material and sample problems, followed by understanding and presenting the content.

Students were encouraged to explore learning materials and relevant information on trigonometry from various sources. Through guided group discussions, with support from the teacher, students actively collaborated and analyzed the gathered information. They also identified sample problems along with complete solution steps. This process aimed to deepen students' problem-solving skills in mathematics.

Once the group work was completed, each group presented their discussion results to the class, while other groups were invited to provide feedback. At the end of the session, the teacher administered several practice problems related to the trigonometry material previously presented, to measure the students' problem-solving ability. The results of this test were used as an **observation tool** to assess whether there was improvement compared to the previous cycle. After the learning activities concluded, the teacher wrapped up the session with a summary, a closing prayer, and a farewell.

Observe (Cycle II)

The observe followed the acting stage, as in Cycle I. During this phase, the teacher observed the learning process and students' activities in the classroom. The observation aimed to assess both the implementation of the lesson and students' performance in solving mathematical problems. Improvements were evident through an increase in students' average evaluation scores and the percentage of students who solved the problems using the correct steps.

Reflect (Cycle II)

After completing Cycle II, the teacher conducted a reflection session. Based on observations, students appeared more active in group discussions compared to Cycle I, although a few remained less engaged. During discussions, students asked questions and explained concepts to each other, making it easier to understand the material. Students became more involved in their groups, trying to solve mathematical problems they had collected.

Improvement was observed in student participation, particularly during presentations and while writing answers on the board. Although a few students were passive during other groups' presentations, most paid close attention. A similar pattern was seen when the teacher reviewed answers on the board—most students remained attentive.

A significant enhancement in students' ability to comprehend and solve problems was also noticeable compared to Cycle I. Students were more meticulous in noting the given information in a problem, and nearly all of them were able to correctly interpret and solve the problem. In Cycle II, more students completed the problems using the appropriate problem-solving steps: understanding the problem, devising a plan, carrying out the plan, and interpreting the solution

After conducting a series of processes from Cycle I to Cycle II, it can be concluded that the application of the Project-Based Learning (PjBL) approach led to an improvement in students' mathematical problem-solving abilities. This improvement is shown in Table 1 below:

Table 1. Evaluation Results of the Application of PjBL Approach to Students' Mathematical Problem-Solving Ability.

Indicator	**Cycle I**		**Cycle II**	
Answering questions *not* according to problem-solving steps	18	56%	6	19%
Answering questions *according* to problem-solving steps	14	44%	26	81%

Table 1 presents data on students' abilities in solving mathematical problem-solving tasks, specifically whether they followed the correct steps of the problem-solving process. In Cycle I, 18 students, or 56%, answered the problems without following the appropriate problem-solving steps. However, in Cycle II, this number significantly decreased to only 6 students, or 19%. This decrease indicates a substantial improvement in students' skills after implementing the Project-Based Learning (PjBL) approach.

Conversely, the number of students who were able to solve the problems using the correct steps increased from Cycle I to Cycle II. In Cycle I, only 14 students, or 44%, successfully followed the structured problem-solving steps, whereas in Cycle II, this number increased to 26 students, or 81%. This improvement highlights that the application of the PjBL approach had a positive impact on students' mathematical problem-solving skills.

From this data, it can be concluded that the PjBL approach significantly enhanced students' problem-solving abilities. Students who followed the correct sequence of problem-solving steps demonstrated a strong understanding of the mathematical processes involved (Astutiani et al., 2019). The percentage of students able to answer correctly using the proper steps increased by 37%, from 44% in Cycle I to 81% in Cycle II. On the other hand, the percentage of students showing low problem-solving ability decreased by 37%, from 56% in Cycle I to only 19% in Cycle II.

Mathematical problem-solving requires a structured and systematic thought process. According to Polya (1978), there are four main stages in solving mathematical problems:

1. Understanding the problem – identifying given information and comprehending what is being asked. This stage ensures students have a clear grasp of the problem before attempting to solve it.
2. Devising a plan – selecting appropriate formulas and linking known information to derive unknown values. This step involves creating a logical strategy tailored to the specific problem.
3. Carrying out the plan – substituting values into formulas and performing calculations. This stage demands accuracy and attention to detail to ensure correct results.
4. Looking back (reviewing) – verifying the final answer to ensure it aligns with the question. At this stage, students may also explore alternative methods for deeper understanding and reflection.

The implementation of project-based learning has been proven to improve students' mathematical problem-solving skills. By engaging in relevant and collaborative projects, students can develop their creativity and apply ideas in meaningful, concrete outcomes. This approach not only enhances content comprehension but also provides students with practical and reflective learning experiences.

Conclusion

Based on the results of the classroom action research conducted, it can be concluded that the application of the PjBL approach improves the mathematical problem-solving abilities of Class X MIPA 1 MAN Kota Blitar students. The results of student learning evaluations show an increase in mathematical problem solving abilities. In cycle I, as many as 14 students or 44% showed good mathematical problem-solving abilities in cycle I, while in cycle II the number increased to 26 students or 81%. The percentage of students with good mathematical problem solving abilities increased by 37% from cycle I to cycle II

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