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Improving students' mathematics learning outcomes at SMA IT Al-Fityah Pekanbaru through the application of the problem-based learning model

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Abstract

This research is a class action research that aims to improve the learning process and increase students' mathematics learning outcomes by applying the Problem-Based Learning model in a sequence topic. The subjects of this study were 22 students of class XI IPA SMA IT Al-Fityah Pekanbaru even semester of the 2022/2023 academic year with heterogeneous academic abilities. This study consisted of two cycles with each cycle consisting of four stages, namely planning, acting, observing, and reflecting. The results showed an increase in the mathematics learning outcomes of students in class XI IPA SMA IT Al-Fityah Pekanbaru after participating in learning using the Problem-Based Learning model. The increase in students' mathematics learning outcomes can be seen from the frequency of students who reached the Minimum Achievement Criteria (KKM) increased from cycles I and II respectively 63.63% (14 students) in daily test I to 72,72% (16 students) in daily test II. Thus it can be concluded that the Problem Based Learning model can improve the learning process and improve students' mathematics learning outcomes.

Keywords: Student mathematics learning outcomes, Problem-based learning, Classroom action research

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Introduction

Mathematics, as a foundational science, underpins the development of modern technology, playing a crucial role across various disciplines and shaping human thought patterns (Kasri, 2018). Mathematics, as one of the fundamental sciences, plays a crucial role in education. Learning mathematics serves as a means to cultivate scientific thinking in students. Consequently, mathematics lessons should be provided to all students, from elementary school through college (Maesari et al., 2020).

One aspect of the objectives of learning mathematics according to (Permendikbud No.16 Tahun 2022) is that students can understand concepts, think critically, and apply these concepts in real contexts. The achievement of mathematics learning objectives is analyzed from the mathematics learning outcomes that students have obtained in a certain period. Student learning outcomes show the level of student success in learning at school. According to (Susanti &

Kurniawan, 2017) Learning outcomes are defined as a standard measurement guideline for their success in learning the subject matter. Learning outcomes are measured by test scores given for a particular topic. Changes in student behavior after learning ends will determine this (Surya, 2017). The reference for student learning outcomes is the Minimum Achievement Criteria (KKM). Permendikbud Number 21 (2022) states that Minimum Achievement Criteria is a reference for seeing the learning completion of educational units by considering student characteristics, subjects, and conditions of educational units. The Minimum Achievement Criteria can be used as one of the indicators to assess students' mathematics learning completion.

The Minimum Achievement Criteria set by SMA IT Al-Fityah Pekanbaru for the subject of mathematics for the eleventh-grade is 65. The achievement of Minimum Achievement Criteria through information from teachers on daily mathematics tests on the material of mathematical induction is known to have a percentage of 22.72% or 5 out of 22 students who achieved Minimum Achievement Criteria. In the material of linear programs, it shows 45.45% or 10 out of 22 students. Based on the results of learning mathematics, it can be seen that not all students achieve the Minimum Achievement Criteria that have been set.

Observations and interviews were conducted to investigate the ongoing challenges related to achieving the Minimum Achievement Criteria. During the preliminary activities, students were not provided with clear learning objectives, step-by-step instructions, or visible motivation. Additionally, core activities lacked the use of models and learning media. Furthermore, there was no reflection on the learning experiences during the closing activities by the teacher.

In the conducted interviews, it was discovered that three out of five students struggled with understanding mathematics due to their dislike for math lessons. Their test scores were inconsistent and relatively low. When presented with practice questions involving contextual problems, these students expressed difficulty comprehending the problems and solving them.

The combined results of observations and interviews indicate that low mathematics learning outcomes stem from insufficient student engagement in the learning process, a weak grasp of fundamental concepts, and challenges in solving context-based problems. To address this, the existing learning process must be enhanced. Implementing an effective learning model—one that actively engages students—can lead to improved mathematics results, particularly in problem-solving skills.

The Problem-Based Learning (PBL) model is a model in learning that requires active participation or involvement of students in the problem-solving process (Sriwati, 2021). The Problem-Based Learning (PBL) model, within the context of education, employs real-world problems to enhance students' critical thinking skills during the problem-solving process (Yanti, 2017; Saputri et al., 2019). As a result, it is expected that students will gain a better understanding of the material and experience improvements in learning outcomes.

According to (Anugraheni, 2018), the PBL model prioritizes the problem-solving and critical thinking of students as a means of gaining knowledge and concepts. This model requires student participation in learning activities. The PBL model is described as a plan of activities or learning activities based on real problems, either at school, at home, or in the community. Constructivism theory is in line with the PBL model, which focuses on how students learn. According to (Kusumawati et al., 2022), constructivism theory involves students actively

participating in constructing the ideas taught so that they can implement knowledge in everyday life. In its implementation, the PBL model consists of 5 stages. According to the Sofyan et al. (2017), there are five main flows in the PBL model, namely (1) orienting students to problems; (2) organizing students to learn; (3) guiding individual and group investigations; (4) developing and presenting work results; and (5) analyzing and evaluating the problem-solving process.

The Problem-Based Learning (PBL) model emphasizes active student involvement in the learning process. Within the context of sequences, students encounter real-world problems that demand a deep understanding and practical application of mathematical concepts to arrive at solutions. For instance, they might tackle tasks such as modeling population growth, analyzing financial patterns, or predicting trends in scientific data. These activities not only enhance their ability to calculate and apply formulas but also foster critical, analytical, and creative thinking skills. PBL enables students to integrate diverse mathematical concepts and cultivate sophisticated problem-solving abilities, which are essential competencies in the real world (Ananda et al., 2022)

Furthermore, incorporating Problem-Based Learning (PBL) into sequence-based education can enhance student motivation and engagement. When students grapple with authentic problems that demand an understanding of sequences and series for resolution, they become more motivated to learn and apply these mathematical concepts. Additionally, the PBL model fosters collaborative work, idea-sharing, and joint solution development among students—essential skills for success. Numerous studies have demonstrated that implementing the PBL approach positively influences students' mathematics learning outcomes (Hasanah & Himami, 2021). This is following the research of (Sholikhakh et al., 2019) which revealed that mathematics learning outcomes increased after the implementation of the PBL model. In line with that, (Jayantika et al., 2020) In his research also stated that by implementing the PBL model there was an increase in students' mathematics learning outcomes. The aforementioned issues highlight the need for improvements in the learning process to enhance the mathematics learning outcomes of Eleventh-Grade IPA students at SMA IT Al-Fityah Pekanbaru, particularly in the area of sequences. This study can actively engage students in their learning and contribute to improved mathematics performance. For educators, the Problem-Based Learning (PBL) model serves as an alternative approach that can be applied effectively in mathematics education. Schools can use the findings from implementing the PBL model as input to enhance the overall quality of mathematics instruction. Additionally, researchers can benefit from this study by gaining deeper insights into the practical application of the PBL model.

Method

This study constitutes a classroom action research that applies the Problem-Based Learning (PBL) model to enhance the learning process and improve students' mathematics outcomes. The research took place during the even semester of the 2022/2023 academic year in Eleventh-Grade IPA Students at SMA IT Al-Fityah Pekanbaru. The intervention commenced on Monday, March 6, 2023, and continued until Monday, May 22, 2023. The study involved 22 students—12 males and 10 females—with varying levels of ability.

The intervention was conducted collaboratively with teachers from Eleventh-Grade IPA Students at SMA IT Al-Fityah Pekanbaru, focusing on mathematics subjects. Mathematics education students served as observers during this study. The research comprised two cycles, each consisting of four stages: 1) planning, 2) acting, 3) observing, and 4) reflecting. Cycle I involved three meetings, while Cycle II included four meetings and a daily test for each cycle. The stages of each cycle are illustrated in Figure 1.
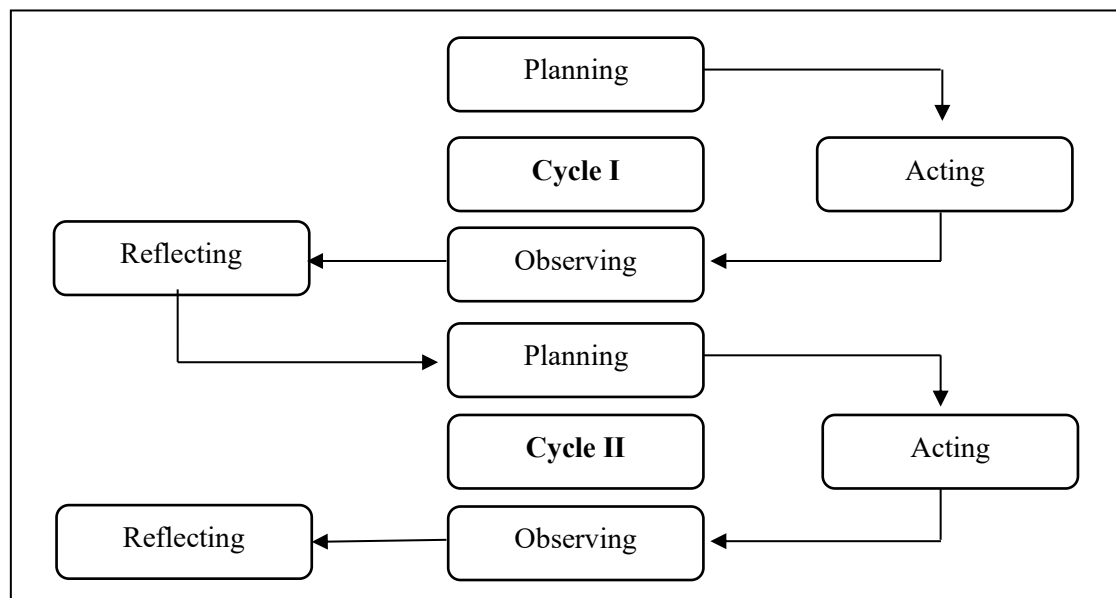

Figure 1. Classroom Action Research Cycle

During the planning stage, preparations are made for the implementation of classroom action research. These preparations include creating a syllabus, a Learning Implementation Plan (RPP), learning materials, Student Activity Sheets (LAS), and the necessary instruments for the research cycle. Additionally, at this stage, student groups are formed based on academic ability and gender, using basic scores as a criterion.

The implementation stage follows the planning stage. Researchers utilize the Problem-Based Learning (PBL) model to enhance the learning process and improve students' mathematics outcomes. Simultaneously, the observation and implementation stages occur. Observations help assess the effectiveness of the intervention and identify any weaknesses that require improvement to achieve desired goals. Finally, the reflection stage involves analyzing the observed results to inform the creation of a new plan. These reflections serve as the foundation for preparing the next cycle of action.

The instruments employed to assess students' mathematics learning outcomes in this classroom action research included two types: 1) observation sheets used to monitor the implementation of the Learning Implementation Plan (RPP), and 2) tests consisting of essay questions to measure students' abilities. These instruments were utilized during each cycle, with student mathematics learning outcome test sheets administered at the end of each cycle. The study collected data through observation sheets, which tracked student and teacher activities during the learning process. Additionally, mathematics learning outcome tests—specifically the Cycle I and Cycle II daily tests—provided data on students' mathematics

learning outcomes. The daily test questions were designed based on the indicators related to the main topic of Geometric Sequence.

The data obtained from observing teacher and student activities were analyzed descriptively. This analysis described how teachers and students behave during the learning process implementation. The purpose of this analysis was to assess the suitability of planning and implementation. Additionally, student mathematics learning outcome data were analyzed using descriptive statistical techniques, and frequency distribution tables were employed to analyze data before and after the intervention. Students are considered successful if their level of achievement in mathematics learning outcomes meets the Minimum Achievement Criteria (which is 65) set by the school.

When problems studied in each cycle are increasingly solved, classroom action research is considered successful. The criteria for measuring the success of this study include: (1) Improving the learning process, as defined by better teacher and student activities. The steps for implementing the problem-based learning model have been adjusted to align with the actions taken during the learning process. These adjustments are reflected on the observation sheet for each meeting; and (2) Enhancing students' mathematics learning outcomes. This improvement is evident through the analysis of frequency distribution data related to the achievement of Minimum Achievement Criteria for students' mathematics learning outcomes. The data shows that students' mathematics learning outcomes have improved. The two criteria are considered achieved if, after implementing the action, the number of students meeting the Minimum Achievement Criteria increases and/or the quantity of students falling short of the criteria decreases from before the action to after it.

Results

In the first cycle, two meetings and one daily test were conducted. By analyzing observation sheets and engaging in discussions with observers, both teacher and student activities were assessed. The results of these discussions revealed strengths that should be maintained and weaknesses that require improvement. Specifically, the strengths observed during the learning process are as follows: (1) Active Student Engagement: Efforts were made to involve students in every activity, including apperception and lesson conclusions; (2) Formative Assessment: A formative test was administered to assess whether learning objectives had been achieved; and (3) Timely Communication: Students received information about the material for the next meeting during each session.

The weaknesses observed during Cycle I actions, along with the efforts to improve Cycle II actions, are as follows: (1) Time Allocation: The time allocated for each implementation did not align with the plan, resulting in some activities being left incomplete due to time constraints. Consequently, there was insufficient opportunity for reflection and reinforcement of learning materials. To address this, effective time management strategies were implemented to ensure that each stage of learning proceeded smoothly and according to the plan; (2) Student Participation: During apperception, motivation, and problem identification activities, only a few students actively asked questions or provided responses. It is essential to continue training students to express their opinions confidently and courageously. Encouraging student engagement in these discussions fosters a more dynamic learning environment; and (3) Group

Discussions: Students were not accustomed to group discussions. When working on Learning Activity Sheets (LAS), some students would immediately approach the teacher without first discussing the material within their groups. To address this, capable students within each group were encouraged to assist their peers who struggled to understand the content.

The results from Cycle I indicated that only 63.63% of students achieved the Minimum Achievement Criteria (KKM). Specifically, out of 22 students, 14 successfully completed the requirements, while 8 did not. Consequently, it is evident that the actions taken during Cycle I were not entirely successful, necessitating further improvements in Cycle II.

The second cycle involved four meetings and one daily test. In Cycle II, improvements were made to deficiencies identified during the reflection phase of Cycle I. As a result, the learning process demonstrated enhanced implementation compared to Cycle I. Students became more active in participating, responding during apperception, providing motivation, identifying problems in Learning Activity Sheets (LAS), and concluding learning materials. Additionally, students exhibited orderliness during group formation and problem-solving activities. Their familiarity with the learning process during Cycle II made directing them less challenging. Overall, significant positive changes were observed in the activities carried out by both teachers and students. The results of Cycle II showed that 72.72% of students achieved the Minimum Achievement Criteria (KKM), with details for 22 students: 16 completed the requirements, while 6 did not. These results were quite satisfactory, leading to the declaration of success for the actions taken in Cycle II, which did not require continuation in the subsequent cycle.

The analysis of mathematics learning outcomes for Eleventh-Grade IPA students at SMA IT Al-Fityah Pekanbaru, following the implementation of the Problem-Based Learning (PBL) model on the main topic of sequences, is depicted in Figure 2:
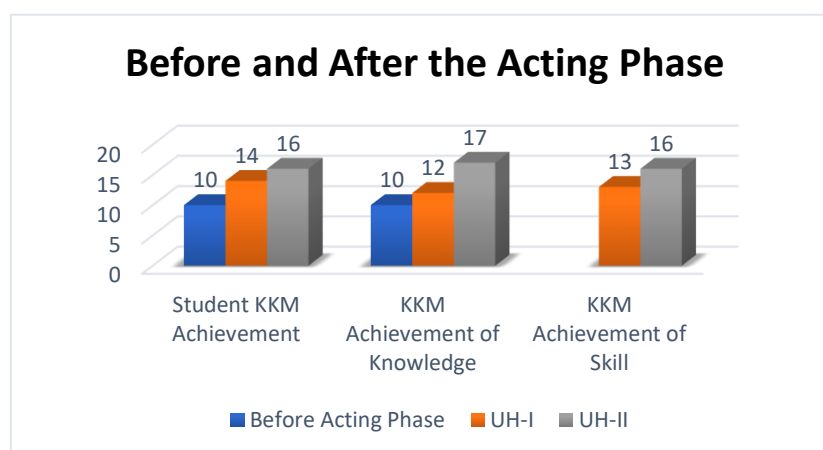

Figure 2. Student Mathematics Learning Test Results Diagram

Referring to Figure 2, a total of 14 students successfully achieved the Minimum Achievement Criteria (KKM) in UH-1, with an additional 2 students meeting the KKM in UH-II. Specifically, 12 students met the KKM knowledge competency standard in UH-I, while in UH-II, this number increased by 5 students compared to UH-I. Furthermore, the KKM skill competency standard was successfully met by 3 more students in UH-II than in UH-I.

Table 1. Frequency Distribution of Students' Mathematics Learning Outcomes

Interval Score	Students' Frequency		
	Basic Score	Score UH-I	Score UH-II
29 − 40	4	-	-
41 − 52	4	2	1
53 − 64	4	6	5
65 − 76	4	4	6
77 − 88	3	7	6
89 − 100	3	3	4

Table 1 presents the frequency distribution describing students' mathematics learning outcomes. It illustrates the distribution of scores, ranging from those who did not meet the standard (basic score) to those who achieved the Minimum Achievement Criteria (KKM) after the action (UH-I and UH-II). According to the table, in UH-I, 14 students achieved the Minimum Achievement Criteria, while in UH-II, this number increased to 16 students..

Discussion

The analysis of teachers' and students' activities during the implementation of the PBL (Problem-Based Learning) model reveals a positive impact on the learning process. Researchers' observations indicate that the model has been effectively delivered to students. As a result, students are able to complete learning activities successfully and promptly, collaborate in groups to solve teacher-assigned problems, and confidently present their group work to the class (Husnidar & Hayati, 2021). This is in line with (Astuti et al., 2021; Defiyanti & Sumarni, 2020; Putri & Zuryanty, 2020) that learning focuses on students and learning is more meaningful, learning is more active and through problem solving activities carried out it can improve students' memory.

The increase in student activity is based on the characteristics of the PBL model. According to (Fauzia, 2018), these features include the application of contextual learning, active student engagement, motivation through problem-solving tasks, collaborative group discussions, and diverse conceptual understanding, skills, and experiences. Specifically, in UH-I, 14 students met the KKM (Minimum Achievement Criteria), while in UH-II, this number increased to 16 students. Furthermore, for the knowledge aspect, 12 students achieved the KKM in UH-I, and 17 students did so in UH-II. Similarly, in terms of skills, 13 students met the KKM in UH-I, and 16 students did so in UH-II. These results highlight the positive impact of the PBL model on students' mathematics learning outcomes, aligning with previous studies demonstrating its effectiveness (Kartiwi, 2021). Analysis of mathematics learning outcomes data shows that there is an increase in the number of students who are able to meet the KKM after the action compared to the number of students who meet the KKM before the action. In line with Hesti (2019) which revealed that there was an increase in students' mathematics learning outcomes on the sequence material after the PBL model application action.

Based on the analysis of teacher and student activities, as well as the assessment of students' mathematics learning outcomes, the criteria for successful action have been met. This indicates an improvement in the learning process and an increase in students' mathematics performance. The proposed hypothesis suggests that implementing the PBL (Problem-Based Learning) model in mathematics education positively impacts the quality of learning and enhances the outcomes for the Eleventh-Grade IPA students at SMA IT Al-Fityah Pekanbaru

during the even semester of the 2022/2023 academic year, specifically focusing on the topic of sequences. The validity of this hypothesis can be accepted.

Conclusion

Based on the study results and discussions, it can be concluded that implementing the PBL (Problem-Based Learning) model for the main topic of sequences improves the learning process and enhances mathematics students' outcomes in the Eleventh-Grade IPA Students at SMA IT Al-Fityah Pekanbaru. Specifically, the researcher found that student success in applying the PBL model increased by 13.64% from cycle I to cycle II. In cycle I, the completion rate was 63.63%, which rose to 77.27% in cycle II. This study serves as a recommendation for mathematics teachers to consider using the PBL model as an alternative approach. When applying the PBL model, effective time management is crucial to ensure each stage is carried out optimally.

Declarations

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