Volume 5, Number 1, December 2023
Journal of Research on Mathematics Instruction
DOI: https://doi.org/10.33578/jrmi.v5i1.88
Journal's Webpage: http://jrmi.ejournal.unri.ac.id

Implementing the Problem-Based Learning (PBL) Model to Improve Learning Outcomes in Probability in Junior High Schools

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ARTICLE'S INFORMATION

Article history:

Received: Mar-21-2024

Reviewed: Mar-27-2024

Accepted: Jul-12-2024

Keywords: Learning Outcomes, Probability, Problem-Based Learning

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ABSTRACT

This study examines the effectiveness of the Problem-Based Learning (PBL) model in enhancing learning outcomes on probability materials among junior high school students. Employing a classroom action research design implemented over two cycles, this study involved eighth-grade students at a public junior high school in Pekanbaru. The PBL method was applied to increase student engagement in learning, facilitate a deep understanding of probability materials, and develop their problem-solving skills. The findings indicate that implementing PBL successfully increased the percentage of students achieving the minimum mastery criterion (KKM) from 30% at the baseline to 65% at the end of the second cycle. This research confirms that PBL is an effective learning strategy for probability materials at the junior high school level, with positive implications for conceptual understanding, social skills, and student learning motivation. These findings suggest that the PBL approach should be more broadly applied in the school mathematics curriculum to enhance mathematics learning outcomes.

INTRODUCTION

Education is a process that builds and develops human potential [1]. According to [2], education is an integral part of development, and the educational process cannot be separated from the development process itself. Development aims to enhance the quality of human resources and the economic sector, which are interconnected and occur simultaneously. Mathematics education is a part of national education that plays a crucial role in developing science and sophisticated technology today.

In educational activities, understanding learners' perspectives towards learning is crucial as a basis for determining the next steps to improve the quality of learning [3]. Based on the researcher's experience at the teaching site, students perceive mathematics as a subject that is difficult to understand, resulting in a significant number of students who fear the subject. This aligns with the findings of [4], which indicate that students still make mistakes in solving given mathematical problems.

Students' lack of understanding of the material is due to their limited engagement in learning. Students also lack good self-regulation. As stated by [5], the self-regulation of some students is adequate, while others are not. The researcher often uses the teaching and learning process centered around the teacher, utilizing lecture methods and a textual approach. Therefore, a change is needed, one of which is shifting from teacher-centered to student-centered learning. Under such conditions, the learning outcomes in mathematics do not meet the established Minimum Mastery Criteria (KKM). Based on the learning outcomes obtained in eighth grade at one of the Junior High Schools in

Pekanbaru, out of 40 students who participated in the daily assessment on the main topic of Statistics, only 12 students achieved the school's set KKM for the mathematics subject, 75. This means only 30% of the eighth-grade students at one of the Junior High Schools in Pekanbaru achieved the KKM on the main topic of Statistics.

Several efforts made by the researcher include forming study groups in class and creating media and teaching aids that can be used to assist the teaching and learning activities. However, these efforts have not significantly impacted students' learning outcomes. This is evident from the daily assessment results of students, many of whom have not achieved the set KKM. The researcher feels the need to innovate in learning implementation. One such innovation is using a learning model to stimulate active student learning, thereby improving learning outcomes.

Understanding the problems the researcher faces in the eighth grade at one of the Junior High Schools in Pekanbaru requires a learning model to optimize student participation in the learning process. A learning model that can help students understand the subject matter to improve learning outcomes by finding their understanding of the material studied through solving contextual problems in daily life and discussing with peers of different abilities. The researcher aims to improve the learning process by implementing a learning model to enhance student's learning outcomes and activities.

Tan stated that the Problem-Based Learning (PBL) model is an innovation in learning because, in PBL, students' thinking abilities are optimized through a systematic group or teamwork process, allowing them to continuously empower, sharpen, test, and develop their thinking abilities [6]. This model can train students in problem-solving, enable teachers to condition students to be actively involved in the learning process, train students' questioning skills, allow students to work collaboratively in groups, and increase students' confidence in communicating the results of their group work in front of the class.

Previous research has examined the use of PBL in mathematics learning. One study found that using a Student Worksheet (LKPD) based on PBL significantly affected students' mathematical communication skills [7]. The difference between that study and the research conducted by the researcher is that the former was a quasi-experimental study examining the effect of using LKPD based on PBL on mathematical communication skills. In contrast, this research is a classroom action study to improve learning outcomes in probability materials through applying PBL. Another study also obtained positive results on applying PBL in mathematics learning. That study's findings stated that using the Problem-Based Learning model could improve the learning process and enhance the mathematics learning outcomes of seventh-grade students at SMP Negeri 40 Pekanbaru [8]. That study differs from the research conducted by the researcher. In that study, the material discussed was set theory for seventh-grade junior high students, while in this research, the material discussed is probability for eighth-grade junior high students.

Based on the description, the researcher will conduct a study titled "The Implementation of the Problem-Based Learning (PBL) Model to Improve Learning Outcomes on Probability Material in Junior High Schools." The Basic Competencies for probability material used in this study are "3.11. Explain an event's empirical and theoretical probability from an experiment, and 4.11. Solve problems related to the empirical and theoretical probability of an event from an experiment."

METHODS

This research was conducted in eighth grade at one of the public junior high schools in Pekanbaru during the second semester of the 2018/2019 academic year. The form of research undertaken was collaborative classroom action research. Classroom action research is observing learning activities collectively through deliberate actions that occur within a class [9]. Collaborative action research is defined as research conducted jointly between the party performing the action and the party observing the process of the action.

The researchers implemented the action while the teacher acted as an observer throughout the learning process. This research followed the stages of classroom action research, which consisted of several cycles. In this study, the researcher used two cycles: the first cycle and the second cycle. According to [9], Classroom Action Research is conducted through 4 stages in each cycle, namely (1) planning, (2) action implementation, (3) observation, and (4) reflection.

In the planning stage, the researcher designed learning tools such as the syllabus, learning implementation plans, and student worksheets arranged with the PBL concept. These learning tools were prepared in accordance with the concept of problem-based learning (PBL). The researcher also prepared the media needed according to the material taught.

In the action implementation stage, the researcher made efforts to improve or enhance the quality of learning in the desired direction by conducting the learning process, referring to the syllabus and lesson plans prepared in the planning stage. Each cycle consisted of two meetings, each lasting for 80 minutes.

The observation stage was carried out in line with the action implementation to see which actions needed improvement in the learning process. This can be observed from the implementation procedures conducted by applying the Problem-Based Learning (PBL) model. Another teacher who collaborated in this research carried out the observation process. The data observed included teacher and student activities during the learning process, with indicators observed referring to the steps in the Problem-Based Learning (PBL) model. Two observation sheets were created: one for teacher and student activities.

In the reflection stage, the researcher discussed the results of the observation of learning activities, especially weaknesses in the learning process that needed to be improved. The results of this reflection could serve as a guideline for concluding the research.

The research instruments used were the learning tools: the syllabus, RPP (Learning Implementation Plan), and Student Worksheets (LKPD). The syllabus in this study included Basic Competencies in knowledge and skills aspects, namely "Explaining the empirical and theoretical probability of an event from an experiment" and "Solving problems related to the empirical and theoretical probability of an event from an experiment". The RPP in this study was prepared for two meetings for cycle I with learning steps using the Problem-Based Learning model. The learning material in RPP 1 was the Probability of a Complement of an Event, while in RPP 2, it was the Expected Frequency of an Event. In accordance with the RPP, the researcher also used two LKPDs where the learning materials presented were tailored to the prepared RPP.

Data was collected through observation and test techniques for mathematics learning outcomes. Observation sheets for student activities were used to obtain data about responses to mathematics learning with the Problem-Based Learning model. Meanwhile, the learning outcome tests were obtained from the student's ability in the classroom to take tests/exercises, both individual and group tests, to obtain data about the students' understanding (learning outcomes) in learning mathematics.

The data obtained through observations and mathematics learning outcome tests were then analyzed. Data on learning activities were analyzed descriptively and narratively, describing what happened during the learning process. Meanwhile, test results were analyzed using the minimum completeness criteria (KKM) for individual learning. Individual learning of KKM was achieved if students obtained at least a score of 75 in accordance with the KKM of mathematics in the research class. The data were then analyzed using percentages. The success of the action was analyzed by comparing the percentage of students achieving the KKM on the baseline score with the learning outcome scores after the Problem-Based Learning (PBL) model was applied, namely on Formative Test I and Formative Test II.

The research subjects were selected using purposive sampling, which was done by selecting one eighth-grade class from the public junior high school in Pekanbaru. This selection aimed to ensure that the research subjects represented the existing population, allowing the research results to be generalized. The student groups were formed heterogeneously based on academic ability and gender to support collaborative learning.

RESULTS AND DISCUSSION

The implementation of this research was carried out through several stages. The first stage was the preparation stage. At this stage, the researcher had prepared research instruments consisting of learning devices and data collection instruments. The baseline score for cycle I was obtained from the daily assessment scores on the main topic of Probability. This baseline score was used to form cooperative groups in Cycle I. Students were grouped into teams of five, resulting in eight groups. The groups formed were heterogeneous in terms of academic ability and gender.

The implementation of the learning process consisted of two cycles. In the first cycle, the concept of complementary probability was discussed, referring to RPP 1 utilizing LKPD 1, and preparing observation sheets for teachers and students. This activity lasted 80 minutes, which is in line with the standard duration of two lesson hours at the school, where one lesson hour lasts 40 minutes. At the beginning of the session, the researcher managed the class and took attendance, noting that 32 students were present and six were absent. The lesson started by directing students' attention to mathematics and introducing the day's topic, namely the probability of an event's complement. By linking the material to real-life applications of probability and emphasizing the importance of positive thinking and continuous effort, students were encouraged to become more involved.

Recalling the previous lesson on probability, the researcher asked students to calculate the probability of rolling a six on a die and confirmed the correct answers from the students. Then, the researcher also conveyed the learning objectives for the day. Students, already divided into groups, were reminded of the learning procedure, which included working on the LKPD in groups and presenting their findings.

As students organized themselves into groups, the researcher distributed the LKPD to each group and reminded them to pay close attention to the problems and questions in the LKPD. While some groups actively discussed, others were distracted. The researcher emphasized the importance of group activities and individual behavior during assessment. Many students appeared unaccustomed to working with LKPD, leading to confusion and inefficient filling of the LKPD, exacerbated by a lack of literacy culture.

Some students were seen copying their friends' work, prompting the researcher to reinforce the importance of discussion and understanding within the group. The 10-minute deadline for preparing the presentation report proved insufficient for the students. Eventually, five groups managed to present their work.

After the presentations, the researcher summarized the lesson with limited participation from students, indicating many were disengaged. A formative test was given but interrupted by the school bell. From observations, it was evident that the implementation of the PBL model did not fully meet expectations with issues such as ineffective time management, students' unfamiliarity with PBL, and using LKPD. For the next meeting, improvements were needed, especially in time management and student engagement, to ensure the implementation of formative tests and the achievement of learning objectives.

Based on the observation sheets during the action, several weaknesses were identified in the actions of both the researcher and the students. These weaknesses included the researcher's inability to manage time effectively, resulting in learning activities not being conducted as planned; students were unaccustomed to working on LKPD, leading to many asking the researcher for assistance; during group work, only the high-ability students worked on the LKPD, while others played and chatted; during the formative test, students felt they lacked time and did not finish all the questions.

Next, the researcher determined the achievement of students' KKM for indicators in the first cycle—the percentage of KKM achievement for indicators in cycle I can be seen in Table 1 below.

Table 1. Percentage of Indicator Achievement on Formative Test I

KD	Competency Achievement Indicators		Number of Students Achieving Minimum Competency Level (KKM)	Percentage (%)
3.11	3.11.1	Identifying the concept of complementary probability of an event	35	87,5
	3.11.2	Determining the probability of a complementary event	8	20
4.11	4.11.1	Solving problems related to the probability of a complementary event	7	17,5

Based on the table of KKM achievement indicators, many students still did not achieve the KKM for each learning indicator. The mistake students made on Formative Test I was a lack of understanding in applying the concept of complementary probability of an event, resulting in a low number of students achieving the KKM. The lowest percentage of students was in indicator 4.11.1 regarding solving problems related to the complementary probability of an event.

Based on the reflection of cycle I, the researcher has developed an improvement plan. Firstly, the researcher will strive to manage time efficiently, ensuring that all planned learning activities are carried out effectively within the designated timeframe. Secondly, during group discussions on completing worksheets, the researcher will guide students to read through all steps to solve problems effectively. Additionally, the researcher will explain to students that copying their peers' work will only be detrimental to them because copying alone does not promote understanding of the given material. Thirdly, the researcher consistently emphasizes that every learning activity involves the assessment of attitude, knowledge, and skills. Fourthly, the researcher directs students to take the formative test seriously as it measures how much they understand the material taught in that session.

In the second cycle, the researcher continues the learning steps from the first cycle while addressing identified shortcomings from the reflection of the first cycle. The second meeting discusses the frequency of expected events, following Lesson Plan 2 and Worksheet 2. All students are present, and before the activity begins, the researcher prepares the classroom and asks students to take out their learning materials. The researcher starts by collecting homework from the previous meeting and motivates students about the importance of learning about the frequency of expected events in daily life, providing an example of prize draws in supermarkets as an application of that concept.

The researcher reviewed previous material on the probability of an event and complementary probability, preparing students with the learning objectives for that day, which include applying the scientific approach and PBL model to solve problems related to the frequency of expected events. Students are reminded of the learning procedures, including group work and presenting discussion results. The researcher organizes students into previously formed groups, and worksheets are distributed in a conducive classroom environment. Instructions are given for group work on the worksheets, and the researcher moves around to monitor and guide students who are having difficulty. Some students are still less participative, but when reminded about assessment, they return to the discussion.

After the discussion, each group is asked to display their work report, and specific groups are selected to present their work results. The researcher invites responses from other groups and provides verbal reinforcement. At the end of the learning session, the researcher guides students to summarize the day's material and provides a formative test to be completed individually.

The learning session ended with collecting formative tests and reading the next material. The researcher also assigns tasks to discuss problems from the textbook as homework. From observations, the learning activities were carried out better than in the previous meeting, with more active participation from students. Although there are challenges within the groups, they can be overcome by reminding students that their activities are assessed, thus refocusing their attention and facilitating good discussions.

From the reflection results, it is known that the implementation of the second cycle is better compared to the first cycle. Students understood and were familiar with the learning steps, resulting in more effective use of time. Students appeared more active in group discussions. The researcher's activities also aligned with the planned implementation of the learning. The formative test was conducted according to the planned schedule. Shortcomings in the first cycle were addressed in the second cycle. For this second cycle, the researcher no longer plans for the next cycle because this research is only conducted for two cycles. The achievement percentage of KKM indicators in cycle II can be seen in Table 2 below.

Table 2. Percentage of Achievement of Indicators in Formative Test II

KD	Competency Achievement Indicators	Number of Students Achieving Minimum Competency Level (KKM)	Percentage (%)
3.11	3.11.3 Determining the expected frequency of an event	31	77,5
4.11	4.11.2 Solving problems related to the expected frequency of an event	26	65

Based on the table above, it can be observed that the percentage of students achieving the minimum competency level (KKM) is lowest in indicator 4.11.2 regarding solving problems related to the expected frequency of an event. The material covered in indicator 4.11.2 requires a good understanding of the concept. Additionally, students also lack an understanding of the prerequisite material supporting this distance learning material, namely the probability of an event and the complementary probability of an event.

The completeness of students' mathematics learning outcomes is also assessed based on the achievement of KKM. Students are considered to have achieved KKM if they obtain a score equal to or greater than the KKM set by the school, which is 75. Based on the test results, the percentage of achievement of KKM in formative test I and formative test II can be calculated, as presented in Table 3 below.

Table 3. Description of Achievement of Minimum Completion Criteria (KKM) for Students

Learning Outcomes	**Before Intervention**	**After Intervention**	
	Initial Score	**Formative Test I**	**Formative Test II**
Number of students achieving KKM	12	15	26
Percentage (%)	30	37,5	65

Based on the table above, it can be observed that there is a change in learning outcomes between the baseline score, formative test I, and formative test II. The percentage of students achieving scores above or equal to the KKM from the baseline to formative test I has increased. This indicates that there has been an improvement in learning outcomes in cycle I. From formative test I to formative test II, the percentage of students achieving scores above KKM has also increased, indicating improved learning outcomes in cycle II.

The significant improvement from cycle I to cycle II can be attributed to several factors. Firstly, the students became more familiar with the PBL model and the use of LKPD, which reduced confusion and increased task completion efficiency. Secondly, the improvements in time management and group dynamics, as addressed in the reflection stage, played a crucial role. The researcher's guidance and emphasis on understanding and discussing the material rather than copying answers also contributed to deeper comprehension and better performance.

Time management can be improved by setting clear time limits for each task and providing gentle reminders to keep students on track. Teachers can use timers and visual aids to help students manage their time better. Additionally, breaking tasks into smaller, manageable steps and ensuring students understand the expectations for each step can prevent delays and keep the class on schedule.

Some students struggled with the LKPD and the PBL model due to unfamiliarity and a lack of prior experience. To help students adapt to this new method, teachers can provide a thorough introduction and training on using LKPD effectively. Before starting the main activities, this can include step-by-step instructions, examples, and practice sessions. Teachers should also encourage a supportive classroom environment where students feel comfortable asking questions and seeking help. Peer mentoring, where more experienced students assist their peers, can also be beneficial. Additionally, teachers should continuously monitor student progress and provide timely feedback and reinforcement to build confidence and competence using the PBL model and LKPD.

Based on the analysis of teacher and student activities, it can be said that implementing the Problem-Based Learning (PBL) model is increasingly aligned with the Lesson Plan (RPP), and the learning process is also improving. In the first meeting, the researcher could not manage time effectively, resulting in some learning activities not being implemented according to the planned schedule. Additionally, students were not yet accustomed to using worksheets in the learning process, resulting in much time being spent during group work. Moreover, many students overwhelmed the researcher in managing the class. However, the researcher reflected on the first meeting so the shortcomings could be rectified for subsequent learning sessions.

These shortcomings serve as improvement points for the researcher in cycle II so that implementing learning can enhance student engagement in learning activities. Although the learning process is imperfect, learning in cycle II is better than in cycle I and has adhered to the lesson plan. This can be seen as all learning activities were carried out according to the planned schedule. Students also began to follow each stage of the learning process. They started to become accustomed to working on worksheets during the learning process, as evidenced by their enthusiasm in completing the work reports.

The results obtained in this study are consistent with previous research findings. Based on a study conducted by [10], the Problem-Based Learning (PBL) model can improve seventh-grade students' learning process and mathematical problem-solving abilities in junior high schools. Based on the learning outcome test analysis, students' mathematics learning outcomes improved from before the intervention to after the intervention. This is indicated by the increase in the percentage of students achieving KKM from the baseline to formative tests I and II. The number of students achieving KKM in the formative test I was 15 (37.5%), while at the baseline, only 12 (30%) achieved KKM. This signifies an improvement between the baseline and formative test I. Similarly, in formative test II, there was an increase from formative test I, with 26 students (65%) achieving KKM. In other words, implementing the Problem-Based Learning (PBL) model in the mathematics learning process for eighth-grade students at one of the State Junior High Schools in Pekanbaru has transformed the learning process in that class. The results of this intervention analysis support the proposed intervention hypothesis, namely that the implementation of the Problem-Based Learning (PBL) model on the Probability core subject can improve the learning outcomes of eighth-grade students at one of the State Junior High Schools in Pekanbaru in the second semester of the 2018/2019 academic year.

CONCLUSIONS AND SUGGESTIONS

Research on implementing the Problem-Based Learning (PBL) model to enhance learning outcomes in probability material at junior high schools has yielded significant results. Through two cycles of action research in the classroom, it has been demonstrated that the PBL model can improve students' understanding of probability concepts, their engagement in the learning process, as well as their collaboration and problem-solving skills. The implementation of PBL enables students to actively participate in learning by resolving contextual problems that are relevant to their daily lives, thereby enhancing their motivation to learn. Challenges encountered, including time management and adaptation to new teaching methods, were successfully addressed through reflection and modification of teaching strategies. Overall, the implementation of PBL has shown a significant increase in the percentage of students achieving the Minimum Completion Criteria (KKM) from the first cycle to the second cycle. Therefore, PBL is recommended as an effective approach in mathematics education, particularly in probability material, to improve students' learning outcomes and learning experiences.

Based on the research findings, several recommendations can be proposed to enhance the effectiveness of the Problem-Based Learning (PBL) model in teaching probability concepts to middle school students. Firstly, time management needs to be improved during class sessions to ensure that all planned activities are completed within the allocated timeframe. This could involve setting clear time limits for each task and providing gentle reminders to keep students on track. Secondly, it is essential to provide comprehensive guidance to students on effectively utilizing Learning Activity

Sheets (LKPD) during group work sessions. Emphasizing the importance of thorough understanding and independent problem-solving is crucial, discouraging reliance on copying peers' work.

Additionally, promoting active participation among all students during group discussions and activities is essential for fostering an inclusive learning environment. Students should be encouraged to contribute actively, ensuring that each voice is heard and valued.

Moreover, reinforcing the idea that individual comprehension is paramount for academic growth is vital. Students should understand that merely copying others' work hinders their learning progress, highlighting the importance of personal engagement and understanding.

Furthermore, consistent reminders about assessment criteria encompassing attitudes, knowledge, and skills throughout each learning activity are necessary. It is crucial to emphasize the significance of active participation and genuine effort in all aspects of their academic journey.

Additionally, encouraging students to approach formative tests with seriousness and diligence is important. They should understand the importance of thorough preparation and effort in achieving optimal results. Lastly, maintaining a proactive approach to monitoring student progress and providing support and guidance is essential. Addressing any challenges or concerns that may arise during the learning process promptly and fostering a culture of continuous improvement in the learning environment through reflective practice is crucial for sustained success in implementing the PBL model.

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DOI: https://doi.org/10.33578/jrmi.v5i1.88
jrmi.ejournal.unri.ac.id, Online ISSN: 2715-6869

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