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Implementation of Problem Based Learning Model on Students' Mathematical Problem-Solving Ability

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ABSTRACT

Mathematical problem-solving ability is an essential competency that students must possess in mathematics learning. However, this ability among eleventh-grade students at SMA Pembangunan Laboratorium UNP remains suboptimal, as reflected in students' difficulties in understanding the problem, devising a strategy, carrying out the solution, and reviewing the results. Therefore, a learning model capable of actively engaging students in the problem-solving process is required, one of which is the Problem Based Learning model. This study aims to analyze whether the mathematical problem-solving ability of students taught using the PBL model is better than that of students taught using the direct instruction model. This study employed a quasi-experimental method with a Non-equivalent Posttest-Only Control Group Design, as the equivalence of the two classes' prior ability was determined based on previous mathematics scores indicating relatively comparable ability. The sample was selected through purposive sampling, namely class XI F5 as the experimental group (31 students) and class XI F6 as the control group (32 students), on the basis of their comparable ability and being taught by the same teacher. The research instrument consisted of a validated essay test of mathematical problem-solving ability with high reliability ($r_{11} = 0.80$), scored using a scoring rubric. The data were analyzed using descriptive statistics and Welch's t-test, as the data did not meet the assumption of homogeneity of variance. The results showed that the mean posttest score of the experimental class (79.03) was higher than that of the control class (62.72), with a significant difference (p-value < 0.05) and a large effect size (Cohen's d = 1.15). Thus, on the topic of Circles in eleventh grade at SMA Pembangunan Laboratorium UNP, the Problem Based Learning model was better than the direct instruction model in improving students' mathematical problem-solving ability.

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Introduction

Mathematical problem solving is an effort made by students to find answers to mathematical problems based on the knowledge they already possess, thereby enabling them to develop the ability to analyze and apply such knowledge to different situations (Ahmad et al., 2024). Mathematical problem-solving ability is one of the primary objectives of mathematics learning. NCTM states that problem solving is a central focus that must be developed in mathematics learning (Sumartini, 2016). This ability is important to develop because it is useful for students in facing the challenges of life in the current era of globalization (Laia & Harefa, 2021). In line with this, BSKAP Kemendikbudristek Number 046/H/KR/2025 states that this ability encompasses the ability to understand the problem, formulate a mathematical model, solve the model, and interpret the solution obtained. Mathematical problem-solving ability emphasizes essential aspects of mathematics, including the application of rules, pattern finding, generalization, and communication in mathematics (Astiana et al., 2021). To analyze mathematical problem-solving ability, this study employs the stages proposed by Polya (1973), namely understanding the problem, devising a plan, carrying out the plan, and looking back at the solution obtained. These steps serve as the reference for solving mathematical problems systematically.

However, in reality, the development of Indonesian students' mathematical problem-solving ability remains suboptimal. Based on the results of the 2018 PISA survey in mathematics, Indonesia only achieved a score of 379 points, a decrease of 7 points from 2015, far below the OECD average of 489 (OECD, 2019). Meanwhile, in 2022, this score declined further to 366, remaining below the OECD average of approximately 472. This places Indonesian students at only Level 2 of mathematical proficiency, indicating that students are able to interpret and recognize, without direct instruction, how simple situations can be mathematically represented. These data reflect the challenges Indonesian students face in mastering the mathematical problem-solving process (OECD, 2023).

Various research findings indicate that Indonesian students' mathematical problem-solving ability still needs to be improved. This condition is supported by the study of Kusumawati et al. (2023) on fourth-grade students at SDN Wonoketingal 01 Demak, which revealed that most students experienced difficulties in solving problems based on the stages of problem-solving ability. Furthermore, Azizah & Kartini (2023) in a study conducted on grade X Science students at IT MAN 1 Pekanbaru, found that students frequently misread the questions, leading to errors in identifying the problem and, consequently, incorrect final answers. In line with this, Rismen et al. (2020) in a study at SMAN 1 Batang Anai, found that students were not yet accustomed to solving non-routine problems and tended to work only on problems similar in form to those exemplified by the teacher, resulting in a lack of optimal improvement in their mathematical problem-solving ability.

A similar condition was also found at SMA Pembangunan Laboratorium UNP. The results of a preliminary test of mathematical problem-solving ability administered to eleventh-grade students indicated that this ability was still low. The preliminary test consisted of three non-routine essay questions developed based on indicators of mathematical problem-solving ability adapted from Lestari & Yudhanegara (2017), namely: (1) stating the information known and asked, (2) formulating a solving strategy, (3) implementing the solving strategy, and (4) concluding the result of the solution in accordance with the context of the problem. The test results showed that, on indicator 1, 56.45% of students obtained a score of 1, indicating that most students were able to state part of the information known and asked, but had not yet been able to identify the information completely and accurately. On indicator 2, 49.13% of students

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obtained a score of 0, indicating that nearly half of the students had not been able to determine a solving strategy appropriate to the given problem. On indicator 3, 46.44% of students obtained a score of 1, indicating that most students still experienced difficulty in carrying out the solving steps correctly and completely to arrive at the correct answer. Meanwhile, on indicator 4, 52.02% of students obtained a score of 1, indicating that most students had not been able to provide a conclusion consistent with the context of the problem, even after completing the solving process. These findings are consistent with the results of observations, which indicated that students were still not actively engaged in the learning process and were not yet accustomed to dealing with non-routine mathematical problems.

Although SMA Pembangunan Laboratorium UNP has implemented the Merdeka Curriculum, classroom learning tends to rely on the direct instruction model. In practice, the delivery of material is largely teacher-centered, while students tend to passively receive and record the information provided. Students have not been optimally engaged in constructing knowledge and exploring problem-solving strategies. In addition, the questions given are generally routine in nature, causing students to become accustomed to applying procedures that have already been demonstrated. As a result, students often struggle to solve non-routine problems that require more in-depth solving strategies. This condition has led to the suboptimal development of students' mathematical problem-solving ability. Based on this condition, an effort is needed to improve students' mathematical problem-solving ability. Such ability can be developed through the implementation of a learning model that requires students to think actively and analyze problems systematically through Polya's steps, namely understanding the problem, devising a plan, carrying out the plan, and looking back at the solution obtained. Therefore, a learning model is needed that is capable of facilitating students in developing this ability so that the learning objectives can be achieved optimally. One learning model possessing these characteristics is the Problem Based Learning model.

Problem Based Learning (PBL) model is a learning model that presents students with real-life problems, with the teacher acting as a facilitator who guides students in solving these problems throughout the learning process (Isrok'atun & Rosmala, 2018). Problem-based learning requires active involvement in critical thinking and problem solving in order to acquire and understand mathematical concepts (Sumartini, 2016). PBL is designed to facilitate students in the process of mathematical problem solving through identifying and analyzing problems, formulating strategies, seeking solutions, and drawing conclusions as evidence-based solutions (Cahyanto et al., 2024). The Problem Based Learning model has a close relationship with mathematical problem-solving ability, as each of its learning syntax stages supports the stages of problem solving. In the stage of orienting students to the problem and organizing them for learning, students are trained to understand the problem and identify the information known and asked. The stage of guiding investigation helps students determine an appropriate solving strategy. Subsequently, in the stage of developing and presenting results, students implement the chosen strategy to obtain a solution. Meanwhile, the stage of analyzing and evaluating the problem-solving process helps students reflect on and draw conclusions from the results obtained. Thus, the syntax of PBL is in line with the stages of mathematical problem solving, thereby having the potential to improve students' mathematical problem-solving ability (Ariyan et al., 2018).

This is supported by the study of Liati et al. (2023), which showed that the PBL model was more effective in improving mathematical problem-solving ability than conventional learning through the presentation of contextual problems that encouraged students to understand the problem, plan a strategy, and independently find solutions. In addition, Faoziyah et al. (2022) also found that PBL significantly improved students' problem-solving ability through investigative and discussion activities that trained students to understand problems, formulate strategies, carry out solutions, and evaluate results. These findings indicate that the PBL model provides students with greater opportunities to develop this ability systematically and meaningfully.

Various previous studies have shown that the Problem Based Learning (PBL) model is able to improve students' mathematical problem-solving ability. However, most of these studies were conducted at different educational levels and on different learning topics, whereas research examining the mathematical problem-solving ability of eleventh-grade high school students on the topic of Circles remains limited. In fact, the topic of Circles contains various contextual problems that require students to understand the problem, plan a solving strategy, carry out the solution, and evaluate the results obtained. Therefore, this study aims to analyze whether the mathematical problem-solving ability of students on the topic of Circles who are taught using the Problem Based Learning model is better than that of students taught using the direct instruction model in the eleventh grade at SMA Pembangunan Laboratorium UNP.

Method

Type of Research

This study employed a quasi-experimental method with a Non-equivalent Posttest-Only Control Group Design. This type of research uses pre-existing classes, making it impossible to randomly assign subjects to the experimental and control classes. In addition, this design was chosen because the researcher did not administer a pretest to the sample classes, in order to avoid the influence of the pretest on learning outcomes. The equivalence of the classes' prior ability was determined based on students' Mid-Semester Summative Assessment scores in mathematics for the eleventh grade. In the experimental class, students were taught using the Problem Based Learning model, while in the control class, students were taught using the direct instruction model. After the treatment was administered, both samples were given a posttest to measure their mathematical problem-solving ability.

Participants

The population of this study consisted of all eleventh-grade students of SMA Pembangunan Laboratorium UNP in the 2025/2026 academic year, totaling 176 students distributed across six classes. The sample was selected using a non-probability sampling technique, namely purposive sampling. This technique was chosen because it determines the sample based on specific criteria or considerations in accordance with the research objectives. Purposive sampling is a sampling technique based on particular (Lestari & Yudhanegara, 2017). Prior to determining the sample, the researcher consulted with the eleventh-grade mathematics teacher to obtain information regarding students' characteristics and their Mid-Semester Summative Assessment scores. Based on the results of this consultation, class XI F5 was selected as the experimental class, with a mean score of 57.81, and class XI F6 was selected as the control class, with a mean score of 57.78, as both classes had relatively similar characteristics and comparable prior ability based on their Mid-Semester Summative Assessment scores. The research sample consisted of 31 students in class XI F5 and 32 students in class XI F6, for a total sample size of 63 students.

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Implementation of the Research

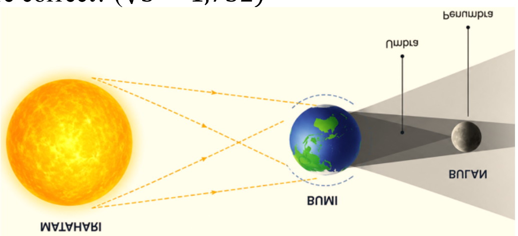
The samples were given treatment in the form of learning using two different models. The experimental class was taught using the Problem Based Learning model through five stages, namely orienting students to the problem, organizing students for learning, guiding investigation, developing and presenting results, and analyzing and evaluating the problem-solving process. Meanwhile, the control class was taught using the direct instruction model through five stages, namely orientation, presentation/demonstration, structured practice, guided practice, and independent practice. Learning activities in both the experimental and control classes were carried out over six meetings, each lasting 2 × 45 minutes. Both classes received the same learning material but were taught using different learning models. The final test was administered in the seventh meeting.

Instruments

The instrument used in this study was a mathematical problem-solving ability test consisting of two essay questions on the topic of Circles. This test instrument was chosen because it is capable of measuring students' ability to understand the problem, formulate a solving strategy, carry out the planned strategy, and review the results in accordance with the indicators of mathematical problem-solving ability. The items of the final mathematical problem-solving ability test are presented in Table 1.

Table 1. Items of the Final Mathematical Problem-Solving Ability Test

Final Mathematical Problem-Solving Ability Test Items	Item Characteristics
 **Question #1 A park architect is designing a circular park** with a radius of 14 meters, with a fountain at its center. Part of the park area will be used as a sector-shaped flower garden, with two alternative designs for the central angle, namely 45° and 60°. Garden lights will be installed along the arc of the sector. Each light can illuminate at most 1 meter of arc length. Help the architect choose the central angle design that results in the fewest number of lights while also producing the flower garden with the smallest area! a. State the information known and asked in the question accurately! b. Formulate the solving strategy to be used to solve the problem in the question! c. Implement the chosen solving strategy to solve the problem in the question! d. Draw a conclusion from the problem solution in accordance with the answer obtained in the question!	Students must understand the concepts of central angle, arc length, and sector area of a circle through a contextual problem. This question requires students to identify the information known and asked, compare two alternative garden designs based on the size of the central angle, apply the formulas for arc length and sector area, and determine the most efficient design based on the calculation results obtained.
Question #2 While observing an illustration of a total lunar eclipse, Haniva wants to understand how the path of sunlight travels toward the Earth and forms a shadow. To do so, she models the Sun and the Earth as two circles, while the path of light is depicted as a line tangent to both circles. From this model, there are two types of light paths, namely the external and internal common tangent lines of the two circles. It is known that the radius of the Sun model is 13 cm, the radius of the Earth model is 3 cm, and the distance between	Students must understand the concepts of the external and internal common tangent lines of two circles through the phenomenon of a lunar eclipse. This question requires students to identify the known elements, select the appropriate tangent line concept, apply the formula for the length of the common tangent line

Final Mathematical Problem-Solving Ability Test Items	Item Characteristics
their centers is 20 cm. Haniva suspects that the external common tangent is longer than the internal common tangent. Is Haniva's conjecture correct? ($\sqrt{3} \approx 1{,}732$)  a. State the information known and asked in the question accurately! b. Formulate the solving strategy to be used to solve the problem in the question! c. Implement the chosen solving strategy to solve the problem in the question! d. Draw a conclusion from the problem solution in accordance with the answer obtained in the question!	of two circles, analyze the correctness of the given conjecture, and present a conclusion based on the mathematical calculation results.

Prior to being used in the study, the test instrument was first validated by two lecturers of Mathematics Education at Universitas Negeri Padang. The validation covered aspects of content, construction, and language. Based on the validation results, both validators stated that the questions were in accordance with the indicators of mathematical problem-solving ability and could be used with several revisions, mainly concerning the narrative and phrasing of the questions to make them easier for students to understand. Based on these suggestions, the researcher clarified the narrative and revised several sentences in the questions before the instrument was used in the study. The instrument was then analyzed in terms of discriminating power, difficulty index, and reliability. The analysis results showed a reliability coefficient of 0.80, which falls into the high category. Thus, the test instrument was considered feasible for use in measuring students' mathematical problem-solving ability. To measure students' mathematical problem-solving ability based on the predetermined indicators, a scoring rubric was used as the assessment guideline. The scoring rubric used in this study is presented in Table 2.

Table 2. Scoring Rubric for Mathematical Problem-Solving Ability

Polya's Stage	Indicator	Score	Description
Understanding the problem	Stating the information known and asked in the problem	0	Does not state the information known and asked in the problem at all
		1	States the information known and asked in the problem, but not sufficiently
		2	States the information known and asked in the problem accurately
Devising a plan	Formulating the solving strategy to be used in solving the problem	0	Does not formulate a solving strategy
		1	Formulates a solving strategy, but not yet correctly
		2	Formulates the solving strategy accurately
Carrying out the plan	Implementing the chosen solving strategy to solve the problem	0	Does not implement a solving strategy
		1	Implements a solving strategy, but it is still incorrect/only a small part of the overall solution is correct
		2	Able to implement the solving strategy accurately, but calculation errors still occur

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Polya's Stage	Indicator	Score	Description
		3	Implements the solving strategy accurately and systematically
Looking back	Concluding the result of the problem solution in accordance with the answer obtained	0	Does not conclude the result of the solution Does not conclude the result of the solution
		1	Concludes the result of the solution, but not yet accurately
		2	Concludes the result of the solution accurately

Data Collection

Research data were collected through a mathematical problem-solving ability test administered at the end of the learning process (posttest). Prior to the administration of the test, the experimental class received instruction using the Problem Based Learning model, while the control class received instruction using the direct instruction model. The posttest results from both classes were then used as research data to compare students' mathematical problem-solving ability.

Data Analysis

The data analysis technique employed aims to draw conclusions in order to test the truth of the hypothesis through the analysis of the final test using appropriate statistics. The analysis began by calculating the test scores based on the predetermined scoring rubric. Subsequently, the mathematical problem-solving ability test scores were converted into a scale of 0 to 100 using the following formula:

$$Final\ Score = \frac{Obtained\ Score}{Maximum\ Possible\ Score} \times 100$$

Subsequently, a descriptive analysis was conducted to obtain the mean, maximum, minimum, and standard deviation values for each class. Prior to hypothesis testing, prerequisite tests were carried out, namely a normality test (Anderson-Darling test) and a homogeneity of variance test (F-test), at a significance level of 5%. Hypothesis testing in this study was conducted at a significance level of 5% using Welch's t-test (t'-test), as the variances of the two groups were not homogeneous. This test was used to determine whether the mathematical problem-solving ability of students taught using the Problem Based Learning model was better than that of students taught using the direct instruction model. This testing process was assisted by Minitab software to ensure the accuracy of the analysis results.

Research Findings

Data Description

The research data were obtained from the results of the mathematical problem-solving ability test administered to students in the experimental and control groups after the learning process had been completed. To obtain a general overview of students' mathematical problem-solving ability in both classes, a descriptive analysis was conducted. The results of the descriptive analysis are presented in Table 3.

Table 3. Descriptive Analysis of Sample Mathematical Problem-Solving Ability

Group	Mean	Highest Score	Lowest Score	Standar Deviation
Experimental	79.03	94.44	61.11	10.01
Control	62.72	88.89	11.11	17.45

Based on Table 3, it can be seen that the mean score of the experimental group was 79.03, while that of the control group was 62.72. This indicates that the mathematical problem-solving ability of students in the experimental group was better than that of students in the control group. Based on the analysis results, the control group had a larger standard deviation than the experimental group. This finding indicates that students' ability in the control group was more varied, resulting in a wider spread of scores, whereas the experimental group was more homogeneous, as its scores were more evenly distributed around the mean.

The results of the mathematical problem-solving ability test for both sample groups can also be seen through the mean score for each indicator, as presented in Table 4.

Table 4. Mean Scores of Students' Mathematical Problem-Solving Ability in the Sample Groups for Each Indicator

Indicator	Maximum Score	Mean Score	
		Experimental	Control
Stating the information known and asked in the problem	2	1.85	1.42
Formulating the solving strategy to be used in solving the problem	2	1.31	0.87
Implementing the chosen solving strategy to solve the problem	3	2.40	2.15
Concluding the result of the problem solution in accordance with the answer obtained	2	1.55	1.23

Based on Table 4, it can be seen that the mean scores of students' mathematical problem-solving ability test on all indicators were higher in the experimental group than in the control group. Thus, it can be concluded that the mathematical problem-solving ability of students in the experimental group who learned using the PBL model was better than that of students in the control group who learned using the direct instruction model.

Analysis of Mathematical Problem-Solving Ability Test Data

Data analysis was conducted to determine the acceptance or rejection of the research hypothesis. Prior to hypothesis testing, prerequisite tests were first carried out, comprising normality and homogeneity of variance tests. Data processing was performed with the assistance of Minitab software, and the results are presented in Table 5.

Table 5. Results of the Prerequisite and Hypothesis Testing

Test	*P-value*	Criterion	Decision
Normality Test – Experimental Group (*Anderson-Darling*)	0.069	*P-value* > 0,05	H_0 accepted
Normality Test – Control Group (*Anderson-Darling*)	0.254		
Homogeneity of Variance Test (Uji-*F*)	0.003	*P-value* < 0,05	H_0 rejected
Hypothesis Test (Welch's t-test)	0.000		

Based on Table 5, it was found that the data of both the experimental and control groups were normally distributed. The results of the homogeneity test showed that the variances of the two groups were not homogeneous. Furthermore, the results of the hypothesis test indicated that the mathematical problem-solving ability of students who learned using the PBL model was better than that of students who learned using the direct instruction model.

To determine the magnitude of the effect of implementing the Problem Based Learning model on students' mathematical problem-solving ability, an effect size analysis (Cohen's d) was conducted. This analysis provides information regarding the strength of the influence of the applied learning model, thereby indicating not only the statistical significance but also the practical significance of the research findings. The results of the effect size calculation are presented in Table 6.

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Table 6. Effect Size Test Results

Parameter	Value
Effect Size (Cohen's d)	1.15
Category	Large

Based on Table 6, the effect size (Cohen's d) of 1.15 falls into the large category. This finding indicates that the implementation of the PBL model not only produced a statistically significant difference but also had a strong impact on improving students' mathematical problem-solving ability.

Discussion

The results of this study indicate that the mathematical problem-solving ability of students who learned using the Problem Based Learning model was better than that of students who learned using the direct instruction model. This is reflected in the mean posttest score of the experimental group, which was 79.03, compared to 62.72 for the control group. Furthermore, the results of Welch's t-test showed a p-value of $0.000 < 0.05$, thereby confirming that the research hypothesis was accepted. Thus, the mathematical problem-solving ability of students who learned using the PBL model was better than that of students who learned using the direct instruction model. In terms of each indicator of mathematical problem-solving ability, the experimental group obtained a higher mean score than the control group on all indicators. On the indicator of stating the information known and asked in the problem, with a maximum score of 2, the mean score of the experimental group was 1.85 (92.50%), while that of the control group was 1.42 (71.00%). On the indicator of formulating the solving strategy to be used in solving the problem, with a maximum score of 2, the experimental group obtained a mean score of 1.31 (65.50%), while the control group obtained 0.87 (43.50%). On the indicator of implementing the chosen solving strategy to solve the problem, with a maximum score of 3, the experimental group obtained a mean score of 2.40 (80.00%), while the control group obtained 2.15 (71.67%). Meanwhile, on the indicator of concluding the result of the problem solution in accordance with the answer obtained, with a maximum score of 2, the experimental group obtained a mean score of 1.55 (77.50%), while the control group obtained 1.23 (61.50%). These data indicate that learning with the PBL model yielded better outcomes on all indicators of mathematical problem-solving ability.

On indicator 1, all students were able to identify and state the information known and asked in the problem. However, the experimental group obtained the maximum score (score 2) more frequently than the control group. This indicates that the experimental group was more thorough in stating the known and asked information, using either mathematical language or their own words. In contrast, some students in the control group still stated the information incompletely or omitted the information asked. This condition was influenced by the stages of orienting students to the problem and organizing students for learning in the PBL model, which trained students in understanding the problem and identifying important information prior to solving it. Thus, students in the experimental group demonstrated better ability on indicator 1.

On indicator 2, the experimental group also obtained a higher score than the control group. This indicates that the experimental group was able to formulate a more complete and systematic solving strategy, supported by relevant formulas or mathematical concepts. Meanwhile, the strategy formulated by the control group was still incomplete, and thus did not fully depict the solving steps. This is related to the stage of guiding investigation in the PBL model, which encourages students to independently plan a solving strategy. Thus, the experimental group demonstrated better ability on indicator 2.

On indicator 3, the experimental group also obtained the maximum score more frequently than the control group. This indicates that students in the experimental group were able to implement the solving strategy accurately and correctly, whereas students in the control group still made calculation errors or inaccuracies in implementing the strategy due to flawed planning. This condition was influenced by the stage of guiding individual and group investigation in PBL, in which students were given the opportunity to implement their strategy while receiving guidance. Thus, the experimental group demonstrated better ability on indicator 3. On indicator 4, the experimental group was likewise superior to the control group. This is reflected in the ability of students in the experimental group to draw complete conclusions and interpret the results in accordance with the problem. In contrast, some students in the control group merely stated the final result without interpretation, resulting in incomplete conclusions. This is related to the stage of analyzing and evaluating the problem-solving process in PBL, which trains students to reflect on their results. Thus, the experimental group demonstrated better ability on indicator 4.

The success of implementing the PBL model in this study was also supported by the use of the student worksheet, which was designed in accordance with the syntax of PBL and the indicators of mathematical problem-solving ability. In the initial part of the student worksheet, students were directed to state the information known and asked, thereby helping them understand the given problem. Subsequently, the student worksheet contained guiding questions that helped students design a solving strategy. In the solving section, students were asked to implement the chosen strategy and write out the solving steps systematically. In the final section, students were directed to write a conclusion based on the results obtained. Thus, the student worksheet functioned not only as a practice material but also as a means of guiding students through each stage of mathematical problem solving in a structured manner (Nisak & Istiana, 2017).

Based on the description above, the PBL model made students more active through the stages of problem orientation, organization, investigation, presentation of results, and evaluation. This model helped students understand concepts and solve mathematical problems more effectively, as they were directly confronted with contextual problems. This is in line with the studies of Ningsih et al. (2025), Sari & Rani (2025), and Herwandi & Tudjuka (2025) which found that the implementation of the Problem Based Learning model improved mathematical problem-solving ability. Learning in the experimental group was further supported by the use of the student worksheet (student worksheet) in every meeting. In the initial part of the student worksheet, students were directed to state the information known and asked, thereby helping them understand the given problem. Subsequently, the student worksheet contained guiding questions that helped students design a solving strategy. In the solving section, students were asked to implement the chosen strategy and write out the solving steps systematically. In the final section, students were directed to write a conclusion based on the results obtained. Thus, the student worksheet functioned not only as a practice material but also as a means of guiding students through each stage of mathematical problem solving in a structured manner (Nisak & Istiana, 2017).

Meanwhile, the control group was taught using the direct instruction model, which focused on concept explanation, the provision of example problems, and practice. Students tended to follow the solving steps demonstrated by the teacher, and consequently experienced difficulty in solving different problems and determining an appropriate solving strategy. As a result, students' involvement in analyzing problems and formulating solutions was less than optimal, so that their mathematical problem-solving ability did not develop as well as that of the experimental group (Siregar, 2017). Thus, the difference in mathematical problem-solving

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ability between the experimental and control groups is presumed to have been influenced by the difference in the learning processes applied. Based on the description above, it can be concluded that learning with the PBL model is able to improve students' mathematical problem-solving ability.

Conclusion

Based on the results of this study, it can be concluded that students who learned using the Problem Based Learning model demonstrated better mathematical problem-solving ability than students who learned using the direct instruction model on the topic of Circles in the eleventh grade at SMA Pembangunan Laboratorium UNP. This difference in ability is reflected in the results of the final test, which showed that the mean score of the experimental group was higher than that of the control group. This finding is presumed to be related to the characteristics of PBL, which provide students with opportunities to actively understand problems, design solving strategies, implement strategies, and evaluate the results of the solution during the learning process. However, this study has several limitations, namely the absence of a pretest, the involvement of only two sample classes, and the use of a test instrument consisting of only two essay questions. Therefore, further research is recommended to employ a larger sample and more varied instruments.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Auhor Contributions

H.Z. contributed to the development of the research concept, data collection, data analysis, conducting the research, and writing the article. M.L.N. contributed to supervising the research, providing guidance on the research methodology, and refining the content and language of the article. M. and Y.H. contributed to the validation of the instrument and revision of the manuscript. All authors have read and approved the final version of this article for publication. The distribution of contributions to the conceptualization, writing, and revision of this research is as follows: H.Z.: 45%, M.L.N.: 25%, M.: 15%, and Y.H.: 15%.

Data Availability Statement

The authors state that the data supporting the findings of this study can be obtained from the author [H.Z.], upon reasonable request.

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