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# Improving Mathematics Learning Outcomes Through Problem-Based Learning: A Study on Vocational High School Students in Class XI

Mickyal Mashyuri Vebian Lubis [1], Sakur [2], Syarifah Nur Siregar [3]
[1] Pendidikan Matematika, Universitas Riau, Pekanbaru, 28293, INDONESIA
[2] Pendidikan Matematika, Universitas Riau, Pekanbaru, 28293, INDONESIA
[3] Pendidikan Matematika, Universitas Riau, Pekanbaru, 28293, INDONESIA

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***Corresponding address:***

Mickyal Mashyuri Vebian Lubis,
E-mail: mickyalmvl@gmail.com

**ABSTRACT**

This study contributes to improving the learning process of Mathematics among KKBT 1 SMK 4 Pekanbaru Stage 11 students in the school year 2023/2024 and improving their academic performance in Mathematics. The format of this study was classroom action research (CAR) conducted in two cycles, each consisting of six stages: providing motivation, identifying problems, collecting data, processing data, and proving and drawing conclusions. The study subjects were the students of class XI of KKBT 1 SMK 4 in Pekanbaru, totaling 33 students. Data were collected through observation and testing techniques. The tools used included learning tools, teacher and student activity observation forms, and mathematics learning outcome test forms. The data analysis findings showed that the learning process aligned with the lesson plan, and the students were active in the classroom. In addition, the number of students achieving the KKTP increased, i.e., the basic score was 8 or 24.24%; Cycle I increased to 13 or 39.39%; and Cycle II increased to 24 or 72.72%. Thus, through the application of the problem-based learning model, the learning process of the students of KKBT 1 SMK 4 Pekanbaru class XI, stage F, on the material of scatter diagrams for the even-numbered semesters of the academic year 2023/2024 has been improved, and their performance in mathematics has increased.

## INTRODUCTION

Maths is a universal knowledge that benefits people's lives and underpins the development of modern technological advancements. It also has an essential role in various applied disciplines and improves human thinking [1]. In studying maths, students need to think logically and critically, so it is a subject that emphasizes the necessity of analytical, creative, systematic, logical, and collaborative critical thinking skills.

The learning objectives of mathematics mean the importance of learning mathematics for students, so improving mathematics learning outcomes at every level of education needs serious attention. Learning outcomes are competencies that students acquire after learning activities [2]. Wulandari said that learning outcomes are specific competencies or skills, including cognitive, psychomotor, and affective skills, that students acquire after engaging in the teaching and learning process [3]. Hamalik states that learning outcomes are any results achieved by students through specific assessments determined by the programs of their previous educational institutions [4]. The achievement of the mathematics learning process largely determines the success of students learning mathematics.

The achievement of learning objectives can be seen from the mathematics learning outcomes obtained by students. Students can be said to have completed learning mathematics if they obtain learning outcomes that have reached the Minimum Completeness Criteria (MCC). Criteria for achieving learning objectives are a series of criteria or indicators that show the extent to which students have achieved competence in learning objectives. Criteria for achieving learning objectives can help educators improve the learning process and follow-up in accordance with students' competence.

According to the data obtained from the Mathematics Teacher of Class XI KKBT 1 SMKN 4 Pekanbaru for the academic year 2023/2024, there are still a number of students in the class who have not attained the MCC based on the 66-85% numerical range. This data can be seen in the results of the Formative Assessment of the students of Class XI KKBT 1 SMKN 4 Pekanbaru of the even semester of the Academic Year 2023/2024 on the Stage F of the (ATP) Identification of Circular Bowstring, formative assessment results.

Seeing the poor academic performance of the students, the researcher tried to find out the reasons for the poor academic performance by interviewing the maths teachers of class XI KKBT 1 SMKN 4 Pekanbaru. The students still rely on the teacher's explanations, and some others copy their friends' answers, which creates a mismatch of the concepts learned.

In addition to interviewing the teachers, the researcher interviewed two randomly selected students from class XI of KKBT 1 SMKN 4 Pekanbaru. From the findings of the interviews with the students, the researcher learned that most of the students did not actively participate in learning activities and did not pay a lot of attention to the teacher when the material was explained. The students stated they could not solve problems in story form because they lacked the knowledge.

The researcher also conducted observations to learn about the learning process of Mathematics in class XI of KKBT 1 SMKN 4 Pekanbaru to find out what needs to be improved in the learning process. Based on the researcher's observations, the data derived were that in the preliminary activity, the teacher opened the lesson with a greeting and began the learning process by reading a prayer led by the class leader. Then, the teacher asks one student to get or borrow a book from the library and bring it to class while the teacher asks the students about their attendance, gets them ready to learn, and discusses the homework assigned in the last meeting. The teacher provides perception by asking questions related to the material. According to the preliminary activities listed in the Regulation of the Minister of Education, Culture, Research and Technology No. 16 of 2022 on the Standards of the Process of Early Childhood Education, Primary Education, and Secondary Education, the teacher does not communicate the learning objectives to be achieved, nor does he motivate the pupils by giving examples of the benefits of learning the material in everyday life. The teacher does not communicate an explanation of the description of the activities.

It can be seen here that the learning activities refer to [5], which states that the core activities are implemented in accordance with the talents, interests, and physical and mental development of the students in a manner that is interactive, inspirational, fun and challenging, stimulates active participation and provides ample space for student initiative, creativity, and independence to provide ample space for the learning process of ATP. The implementation of the core activities shall also be based on [5], which adopts learning modes, methods, media, and resources appropriate to the characteristics of the students and the subject matter, enabling active student participation. However, based on findings in classroom observations at SMKN 4 Pekanbaru, teachers still predominantly used traditional teacher-centered methods, which did not integrate innovative learning approaches such as

Discovery Learning, Inquiry Learning, and Problem-Based Learning (PBL). This is consistent with previous findings highlighting the limited application of innovative pedagogical models in mathematics education, often resulting in students' passive engagement and low cognitive outcomes [6]. Moreover, effective implementation of such models has been shown to significantly enhance cognitive skills, critical thinking, collaboration, and motivation, as emphasized in recent studies on the integration of Habits of Mind in mathematics learning.

In the closing activity, students were asked to solve problems at home and collect them in the next meeting as the Maths lesson was over. The teacher asks the students to read the material they will study next. The lesson was then closed, and greetings were given. According to [5], in the closing activity, the teacher, together with the students, individually or in small groups, summarises or summarises the learning that has taken place, reflects and evaluates the whole series of learning activities, gives feedback on the learning process and outcomes, and informs about the planning of the learning activities for the next meeting.

Based on the description of the learning process, the researcher concluded that in the learning process of mathematics in class XI of KKBT 1 SMK 4 Pekanbaru, the teacher still leads it because of the lack of participation or motivation of the students, the students still appear to be passive, and most of the students are always dependent on the smarter students to do the practice problems. The students don't understand the concepts well, so it is very difficult for them to work on the form of the story problems.

From the problem description, there is a need to improve the learning process to improve student learning. There is a need for a learning model that will increase students' motivation, motivate them to think critically and independently, be able to apply and relate concepts when they find problems in real life, be able to work actively in a team and solve problems in a fun atmosphere so that learning becomes learner-centered. A problem-based learning model is one of the learning models that can overcome these problems.

Suprijono says that the Problem-Based Learning model is a discovery learning process that includes information, transformation, and evaluation processes [7]. In this case, the problem-based learning model is learning that requires students to discover information about the problem in their learning. According to Arends, problem-based learning is a method in which students solve real problems to sort out their knowledge [7]. This learning mode requires students to solve real problems to build up their knowledge. Therefore, problem-based learning uses problems as authentic learning materials to accumulate knowledge.

The researchers chose the Problem-Based Learning model because the results of previous studies with positive outcomes support it. The results of [8] stated that the learning model develops students' problem-solving thinking skills. Fitriana and Mampouw noted that the opportunities included mathematical material directly related to real life so that the opportunity problem can be expressed as a story problem [9]. Therefore, opportunity is a material to which the problem-based learning model can be applied because it is in everyday life.

Previous studies have demonstrated the effectiveness of the Problem-Based Learning (PBL) model in improving students' mathematics learning outcomes. Research conducted by [10] revealed that implementing PBL in a seventh-grade class at SMPN 23 Pekanbaru significantly enhanced student engagement in the learning process, improved learning outcomes, and encouraged students to participate in discussions and express their opinions actively. The percentage of students meeting the Minimum Completeness Criteria (MCC) increased from 51.2% at the baseline to 66.7% after the

second cycle. Similarly, [11] investigated the application of PBL in probability learning at SMP Negeri 1 Lirik, which increased the percentage of students achieving the MCC from 30% at the initial score to 65% after the second cycle. This study highlighted that the PBL model improved students' conceptual understanding and fostered their social skills and learning motivation. These findings affirm that PBL is an innovative and effective instructional approach for enhancing mathematics learning outcomes, particularly in topics that require contextual problem-solving skills.

## METHODS

The type of research conducted is Classroom Action Research (CAR). The form of classroom action research in this study is collaborative classroom action research, namely researchers and phase f math teachers of class XI SMK 4 Pekanbaru work together to implement the action.

The implementation of this research consisted of two cycles, each consisting of 3 meetings. The implementation of classroom action research was carried out through four stages, namely (1) planning; (2) implementation; (3) observation, and (4) reflection [12].

1. Planning.

In this planning stage, researchers compiled research instruments consisting of learning devices and data collection instruments. Researchers planned the application of problem-based learning models. For its implementation, researchers compiled learning tools consisting of ATP, Teaching Modules (TM) for four meetings, and Learner Worksheets for four sessions. The learning tools were prepared based on the revised independent curriculum. The data collection instruments used included teacher and learner activity observation sheets for four meetings and mathematics learning outcomes test sheets and their alternative answers. In addition, researchers also determined the division of group members based on basic scores. The basic score of students in the first cycle was taken from the students' daily test scores on the previous material.

2. Implementation of Action

Implementation of action is the execution of the planning phase, in which the researcher acts as a teacher who carries out the learning process according to a previously prepared lesson plan. [9] states in a study that action implementation consists of at least two cycles, each consisting of at least two face-to-face meetings. The researchers conducted learning activities according to TM-1 and TM-2, implemented in the first cycle, and TM-3 and TM-4 in the second cycle.

3. Observation

The activities of the teacher and learners during the learning process were observed at the same time and place. The purpose of observation is to determine the quality of implementation or optimization and what needs to be improved to ensure that the executed behavior achieves the desired goal. In this phase, the teacher activity observer was the Mathematics teacher of Phase F of Class XI KKBT 1 SMK 4 Pekanbaru, while the learner activity observer was a fellow researcher. They observed the initial, core, and final activities and then detailed their findings in the observation sheet.

4. Reflection

At this step, the researcher and the teacher observer discussed the findings of the observation of learning practices in each meeting. The researcher discussed the mathematics subject in Phase F of XI KKBT 1 SMK 4 Pekanbaru class with the teacher, how to draw improvements in the studied learning process, and how to develop improvement plans for the next meeting. Reflection is when the teacher or researcher reassesses what has been done after every activity. Data from observation activities and learning outcome tests are analyzed, and the results are used for reflection.

The research subject involved phase f students of SMK 4 Pekanbaru class XI, even the 2023/2024

academic year semester. The research instruments are divided into learning media and data collection. In learning media, the components contain ATP and Teaching Modules. The flow of Learning Objectives used in this study, namely:

1. Identify the concept of a bivariate data scatter diagram
2. Draw and interpret a bivariate data scatter diagram
3. Determine the direction and shape of the trend of bivariate data from a scatter diagram.
4. Detect associations between two categorical variables and between two numerical variables
5. Estimating the best linear model (best fit) on numerical data
6. Differentiating a relationship that is an association from a relationship that is a cause and effect.

The data collected in this study are data on teacher and learner activities during the learning process. The data collection instruments used in this study include:

1. Teacher and Learner Activity Observation Sheet. Teacher and learner activity observation sheets are used to obtain data on teacher and learner activities during the learning process. This becomes material for reflection for the next cycle, Teacher and Learner Activity Observation Sheet. The observation sheet contains the identity of the observation sheet, which consists of: a. Identity of observation; b. instructions for filling; c. aspects of observation.
2. Mathematics Learning Outcome Test Sheet. The mathematics learning outcomes test sheet was used to collect data on students' mathematics learning outcomes after carrying out the learning process using problem-based learning methods. Data was collected through written tests in Summative Assessments 1 and 2. Daily test assessments were carried out to measure students' knowledge, skills, and abilities.

The data collection technique in this study uses observation techniques and technical tests. Observation techniques in data collection are carried out using teacher and student activity observation sheets. The observation sheet is used to observe the implementation of the learning process components, including Analysis educational objectives, learning materials or materials, approaches or methods, media or tools, learning resources, and evaluation with problem-based learning models. The test technique used in this study was a written test carried out on Daily Test I and Daily Test II.

Data Techniques that use Data Analysis of Observations of Teacher and Learner Activities and Data Analysis of Learner Mathematics Learning Outcomes. Data analysis of teacher and learner activities is carried out to answer problem formulations about improving the learning process obtained through observation sheets. Suppose there are still weaknesses or actions that do not follow the steps of the problem-based learning model. In that case, new actions are planned to improve the next learning implementation, such as data analysis of students' mathematics learning outcomes. Data analysis was carried out by looking at the mathematics learning outcomes of individual students. The value of student learning outcomes in UH each cycle is obtained in the following formula:

$$\text{Students' Learning Outcome Completeness (\%)} = \frac{s}{n} \times 100\%$$

Description:
s: number of students who reach KKTP
n: number of students

Learning outcomes improve if students achieve proficient criteria with a score range of 71-80. In this study, the learning process is called an improvement if teacher activity and student activity have increased, where the learning process carried out is getting better from cycle I to cycle II. In addition, there is also a correspondence between the steps of applying the planned problem-based learning

model and the implementation of actions in the learning process, which can be seen from the observation sheet of each meeting.

Then, there was an increase in students' mathematics learning outcomes. The improvement of students' learning outcomes can be seen from the analysis of frequency distribution data and strengthened by the analysis of Criteria for Achievement of Learning Objectives (KKTP). Suppose there is a change in the frequency of students who are in the lower value interval (below KKTP) to a higher value interval (equal to or more than KKTP) from the base value (before the implementation of the action) to the formative assessment I (after the implementation of the action) and from the formative assessment I to the formative assessment II (after the implementation of the action). In that case, it can be said that students' learning outcomes have increased.

## RESULTS AND DISCUSSION

The research was conducted in the even semester of the 2023/2024 academic year from 13 - 24 May 2024. The implementation of the action used two cycles, each consisting of two meetings with one meeting to implement the learning outcomes test. The action was implemented twice a week.

After researchers conducted learning using a problem-based learning model for two meetings, the final test of a cycle I was conducted at the third meeting. Based on the observation sheet, students' learning outcomes are increasing. In addition to the success of the actions in cycle I, researchers and mathematics teachers found strengths and weaknesses that must be improved. The shortcomings in the learning process of cycle I can be seen in Table 1.

Table 1. Shortcomings in Cycle I and Action Improvements

| Disadvantages | Improvement Plan |
|---|---|
| The time allocation planned for each activity does not match the implementation time. | Better timing of implementation to match the planning time. |
| In apperception, motivation, and summarizing learning activities, students have not responded actively to what is conveyed by students who do not respond to the questions presented. | Learners continue to be motivated to get used to expressing their understanding and instill courage in responding. |
| Learners have not identified the problem properly, and there are still errors in the planning and problem-solving aspects. | Learners are guided in solving problems by using problem-solving steps. |
| There are still some students who work individually and only copy the answers of their groupmates. | Learners pay more attention to the learning process to understand the concept and solve questions without recognizing other learners. |
| Learners still do not take the initiative to respond or ask questions about the presentation of the presenting group. | Students continue to be motivated to be more active in responding to the work of their friends' groups, so they are brave enough to express their opinions regarding the material presented. |

Then, cycle II learning was carried out based on the steps and the improvement plan from cycle I. In the learning action of cycle II, it can be seen that the deficiencies that occur in the learning process are getting less when compared to the previous meeting. This shows an improvement in the learning process in Phase F Class XI KKBT 1 SMK 4 Pekanbaru on scatter diagram material.

The learning process of cycle II that has been analyzed, and suggestions for improving its actions are presented in Table 2.

Table 2. Shortcomings in Cycle II and Action Improvements

| Disadvantages | Improvement Plan |
|---|---|
| Learners actively ask researchers about things that have not been understood. Learners ask questions in an orderly manner, and the class atmosphere is conducive, | Students are often encouraged to be more courageous in conveying their difficulties or things not understood in the learning process. |
| Teachers try to use communicative language in conveying learning objectives, materials to be covered, and learning steps to be carried out. | The material students receive is sometimes difficult to accept because the language style is sometimes too formal. |

From the reflection of this second cycle, the researcher did not plan for the next cycle because the research was only conducted for two cycles.

KKTP data analysis was carried out by comparing the percentage of students who achieved KKTP on the basic score before the action and the percentage of students who achieved KKTP after applying the problem-based learning model, namely the Daily Test-I and Daily Test-II scores. The percentage of KKTP achievement of students' math learning outcomes before and after the action can be seen in Table 3.

Table 3. Percentage of KTTP Achievement of Learners.

| | Basic Score | UH-1 | UH-2 |
|---|---|---|---|
| Number of learners who achieve KKTP | 8 | 13 | 24 |
| Percentage of students who achieve KKTP (%) | 24,24 | 39,39 | 72,72 |

Table 3 shows that in UH I, the number of students who reached KKTP was 13 people, and the percentage was 39.39%. In UH II, the number of students who reached KKTP was 24, with a percentage of 72.72%. The percentage indicates that there was an increase in the achievement of students' KKTP from before and after the action.

Frequency distribution data analysis can show the results of the distribution or division of the frequency of students' scores who have not reached the MCC from before the action (base score) to after the action (UH-I and UH-II). The frequency distribution of students' mathematics learning outcomes for each PPA is presented in Table 4.

Table 4. Frequency of Study Results

| Interval | Frequency of Learner Learning Outcomes | | |
|---|---|---|---|
| | Basic Score | UH 1 | UH 2 |
| 0-60<br>New developed | 21 | 16 | 3 |
| 61-70<br>Feasible | 4 | 4 | 6 |
| 71-80<br>Proficient | 2 | 4 | 4 |
| 81-100<br>Skilled | 6 | 9 | 20 |

Based on Table 4, it can be seen that there is an increase in the number of students who are classified as 'skilled' in the basic score to UH 2 and a decrease in the number of students classified as "newly developed". In the basic score, 21 students included "newly developed," while six were classified as" skilled". At UH 1, the number of students classified as "newly developed" had begun to decrease, namely, 16 students, and an increase in the category of" skilled" in UH 2. There was an increase in the 'skilled' category to 9 students. Meanwhile, in UH 2, there was a significant increase, namely, students who were classified as "newly developed" only amounted to 3 students, and the number of students classified as 'skilled' had greatly increased to 20 students.

Learners are declared to have reached KKTP in the 71-100 interval with the proficient and advanced categories. From the data in Table 4, it can be seen that there was an increase in learning outcomes from the basic score to UH 1 by 15.15% or as many as five learners in the proficient criteria. From UH 1 to UH 2, there was also an increase in learning outcomes by 33.33%, as many as 11 students were in the skilled criteria. Thus, problem-based learning can increase the mathematics achievement of students of class X KKBT 1 of SMKN 4 Pekanbaru.

Problem-based learning in this study plays a role in improving student learning outcomes as previous research has been done by several researchers, including research conducted by [7], with the research title "Application of Problem-Based Learning Model to Improve Mathematics Learning Outcomes of Class IV Students of SDN 016 Langgini Kampar Regency". In this class action research, researchers used a problem-based learning model in class IV SDN 016 Langgini, Kampar Regency, to improve student learning outcomes. There was an increase in student learning outcomes from cycle I to cycle II.

The findings of this study align with and extend those of previous research on applying the Problem-Based Learning (PBL) model in mathematics education. Research conducted by [13] showed that the PBL model significantly improved mathematical problem-solving skills among students in class VII-B at MTs PP Nurul Huda Lubuk Batu Jaya, with average scores increasing from 68.61 in cycle I to 86.36 in cycle II. Similarly, research by [14] demonstrated that the PBL model enhanced students' learning outcomes in two-dimensional geometric shapes, where the percentage of students achieving the Minimum Competency Criterion (KKTP) increased from 30.76% before the intervention to 76.92% by the end of cycle II. Additionally, [15] highlighted the effectiveness of innovative approaches, including PBL, in fostering mathematical creative thinking and problem-solving skills, with students' scores improving significantly from pre-test to post-test. These studies corroborate the present research findings, which demonstrate that applying the PBL model improved both the learning process and mathematics learning outcomes, as evidenced by the increase in students achieving KKTP from 24.24% at the baseline to 72.72% in the second cycle. Such consistent improvements across diverse educational contexts underscore the robustness of the PBL approach in fostering active learning and improving student achievement.

Based on the analysis of student and teacher activities and student learning outcomes, it can be concluded that the proposed action hypothesis can be accepted. Thus, the application of the problem-based learning model can improve the learning process and improve the learning outcomes of Phase F class students in class XI KKBT 1 SMK 4 Pekanbaru on the subject matter of linear equations and inequalities of one variable in the even semester of the 2023/2024 academic year. This improvement is evident from the increased percentage of students achieving the Minimum Competency Criterion (KKTP) from the baseline to the second cycle. Furthermore, the results suggest that the problem-

based learning model encourages active student participation and critical thinking, which are essential for mastering mathematical concepts and applying them in real-life contexts.

## CONCLUSIONS AND SUGGESTIONS

Based on the investigation conducted by the researcher, it can be concluded that the application of the problem-based learning model can improve the learning process on variance material**,** is in accordance with the learning objectives to be achieved, and can improve the mathematical achievement of students in class X KKBT 1 SMKN 4 Pekanbaru in the even semester of the 2017/2018 academic year. It is recommended that teachers apply problem-based learning to improve student learning outcomes.

## REFERENCE

[1] Kemdikbud, "Permendikbud Nomor 58 Tahun 2014 tentang kurikulum 2013 Sekolah Menengah Pertama / Madrasah Tsanawiyah." 2014.

[2] S. A. Nugraha, T. Sudiatmi, and M. Suswandari, "Studi Pengaruh Daring Learning terhadap Hasil Belajar Matematika Kelas IV," *J. Inov. Penelit.*, vol. 1, no. 3, pp. 265–276, 2020, doi: 10.47492/jip.v1i3.74.

[3] M. N. Mboa and T. Ajito, "Meningkatkan Hasil Belajar dengan Menggunakan Model Pembelajaran Problem Based Learning (PBL) pada Materi Peluang Siswa Kelas VIII SMPK St. Theresia Kupang," *J. Educ.*, vol. 6, no. 2, pp. 12296–12301, 2024, doi: https://doi.org/10.31004/joe.v6i2.5074.

[4] U. S. Mustakim, "Efektivitas Pembelajaran di Era Normal Terhadap Hasil Belajar Mahasiswa Pada Mata Kuliah Matematika Diskrit," *Uniqbu J. Exact Sci.*, vol. 1, no. 1, pp. 41–45, 2020, doi: https://doi.org/10.47323/ujes.v1i1.15.

[5] Kemendikbud, *Salinan Lampiran Permendikbud No 16 Tentang Standar Proses Pendidikan Dasar dan Menengah*. Indonesia, 2022.

[6] H. M. Siregar, T. Solfitri, Kartini, and A. Permata, "Character Education in Mathematics Learning Through Habits of Mind Development to Support the Achievement of Students' Cognitive Mathematical Ability," *Integr. J. Penelit. Pendidik. Mat.*, vol. 6, no. 2, pp. 140–151, 2024, doi: https://doi.org/10.24905/jppm.v6i2.128.

[7] T. Pamungkas, *Model Pembelajaran Berbasis Masalah (Problem Based Learning*. Jakarta: Guepedia, 2020.

[8] Y. F. Surya, "No TitlePenerapan Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar Matematika Siswa Kelas IV SDN 016 Langgini Kabupaten Kampar," *J. Cendekia J. Pendidik. Mat.*, vol. 1, no. 1, pp. 38–53, 2017, doi: https://doi.org/10.31004/cendekia.v1i1.7.

[9] I. N. Fitriana and H. L. Mampouw, "Skema Kognitif Siswa dalam Menyelesaikan Soal Peluang Ditinjau dari Pendekatan Polya," *Mosharafa J. Pendidik. Mat.*, vol. 8, no. 3, pp. 353–364, 2019, doi: https://doi.org/10.31980/mosharafa.v8i3.572.

[10] S. D. Ananda and E. Liana, "Improving Student Mathematics Learning Outcomes Through the Implementation of PBL Models for Students of Class VII H SMPN 23 Pekanbaru," *J. Res. Math. Instr.*, vol. 4, no. 1, pp. 53–62, 2022, doi: https://doi.org/10.33578/jrmi.v4i1.76.

[11] E. Safitri, "Implementing the Problem-Based Learning (PBL) Model to Improve Learning Outcomes in Probability in Junior High Schools," *J. Res. Math. Instr.*, vol. 5, no. 1, pp. 50–59, 2023, doi: https://doi.org/10.33578/jrmi.v5i1.88.

[12] S. Arikunto, Suhardjono, and Supardi, *Penelitian Tindakan Kelas*. Jakarta: Bumi Aksara, 2021.

[13] T. Avianti, P. Yuanita, and Sakur, "Application of Problem-Based Learning Model to Improve Mathematical Problem-Solving Ability of Class VII-B Students of MTs PP Nurul Huda Lubuk

Batu Jaya," *J. Res. Math. Instr.*, vol. 3, no. 2, pp. 44–53, 2022, doi: https://doi.org/10.33578/jrmi.v3i2.68.

[14] F. Tawassalna and Hasnita, "Implementation of Problem-Based Learning (PBL) Model to Improve Students' Learning Outcomes in Two-Dimensional Geometric Shapes Material," *J. Res. Math. Instr.*, vol. 4, no. 2, pp. 19–28, 2023, doi: https://doi.org/10.33578/jrmi.v4i2.82.

[15] T. Solfitri, H. M. Siregar, Kartini, and A. Permata, "Facilitating Mathematical Creative Thinking Ability: Analysis of Validation, Practicality, and Effectiveness of Learning Modules," *J. Pendidik. Progresif*, vol. 14, no. 1, pp. 619–634, 2024, doi: http://dx.doi.org/10.23960/jpp.v14.i1.202445.

## BIOGRAPHY

Mickyal Mashyuri Vebian Lubis
The author obtained a Bachelor's degree in Mathematics Education at Riau University. The author is reachable via email at mickyalmvl@gmail.com

Sakur
The author obtained her master's degree at Universiti Kebangsaan Malaysia. The author is a lecturer in the mathematics education study program at Universitas Riau. The author is reachable via email at sakur@lecturer.unri.ac.id.

Syarifah Nur Siregar
The author obtained her master's degree at Universitas Pendidikan Indonesia. The author is a lecturer in the mathematics education study program at Universitas Riau. The author is reachable via email at syarifahnur.siregar@lecturer.unri.ac.id.