

## The Effectiveness of Using Problem-Based Learning (PBL) in Mathematics Problem-Solving Ability for Junior High School Students

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### ABSTRACT

This study aims to determine the effectiveness of the Problem Based Learning model in improving students' problem-solving abilities. This is a quasi-experimental study using the Nonequivalent Pretest-Posttest Control Group Design. Students in seventh grade at SMP Negeri 32 Pekanbaru comprised the whole study population. In this research, the sample comprised two classes: VII<sub>3</sub> as the experimental class and VII<sub>1</sub> as the control class. This study utilizes the beginning mathematical ability test (KAM) and the mathematical problem-solving ability test as its instruments. The class of the sample was determined using the KAM test findings. The data were evaluated using the similarity test of two independent sample t-tests, which was preceded by tests for normality and homogeneity of variance. Students who participated in Problem-Based Learning had greater growth in their ability to solve mathematical problems than students who participated in conventional learning.

**Keywords:** Early Mathematical Ability, Problem Based Learning, Problem Solving Ability

### ABSTRAK

Penelitian ini bertujuan untuk mengetahui efektivitas model Problem Based Learning dalam meningkatkan kemampuan pemecahan masalah siswa. Jenis penelitian yang dilakukan adalah penelitian eksperimen semu dan menggunakan desain The Nonequivalent Pretest-Posttest Control Group Design. Populasi pada penelitian ini adalah seluruh peserta didik kelas VII SMP Negeri 32 Pekanbaru. Sampel pada penelitian ini terdiri dari dua kelas, yaitu kelas VII<sub>3</sub> sebagai kelas eksperimen dan kelas VII<sub>1</sub> sebagai kelas kontrol. Instrumen penelitian ini adalah tes kemampuan awal matematis (KAM) dan tes kemampuan pemecahan masalah matematis. Hasil tes KAM digunakan untuk menentukan kelas sampel. Data dianalisis dengan uji kesamaan dua rata-rata Independent Sample T-Test yang didahului oleh uji normalitas dan uji homogenitas varians. Hasil penelitian menunjukkan bahwa peningkatan kemampuan pemecahan masalah matematis peserta didik yang mengikuti pembelajaran dengan model Problem Based Learning lebih baik daripada peserta didik yang mengikuti pembelajaran konvensional.

**Kata kunci:** Kemampuan Awal Matematis, Problem Based Learning, Kemampuan Pemecahan Masalah

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### Introduction

The essential thing in life is education (Ghany, 2018; Rachmawati & Purwandari, 2022; Simatupang & Yuhertiana, 2021; Zahirah, 2021). Human resources can increase with education (Muhammad & Yolanda, 2022; Pitria et al., 2021; Rahman et al., 2022; Saifullah, 2020; Septiana & Salahudin, 2021; Yuliani & Mansur, 2021). Education is the foundation for improving and developing oneself in life (Anggreni et al., 2022; Mahmudah & Putra, 2021; Utami & Musyarofah, 2022; Yuliana & Kusumawati, 2019). So, Education is crucial and can raise the standard of human resources.

Mathematics learning has goals that support national education goals (Muhammad et al., 2022; Suciati et al., 2022). Permendikbud No 58 of (2014) In the 2013 mathematics curriculum, students are expected to: use patterns as conjectures in problem-solving, use patterns as hypotheses in problem-solving, use reasoning on properties, apply mathematical manipulations in simplification, and assess existing components in context mathematics and outside

mathematics includes the ability to understand issues, construct mathematical models, complete models, and analyze the resulting answers, particularly to address daily life situations.

Based on the objectives of the subject, one of the abilities that mathematics students must possess is the ability to solve mathematical problems. According to (Mawaddah & Anisah, 2015; Untarti, 2015) mathematical problem-solving abilities include identifying the known components, the questions being posed, the sufficiency of the needed elements, the ability to develop mathematical models, the ability to choose and create problem-solving approaches, as well as the ability to explain and check the correctness of the offered solutions. According to (Elfiani, 2017; Lastuti, 2018; Nahdi & Cahyaningsih, 2019) not just for those who will investigate or study mathematics in the future but also for those who will use it in other areas of study and my life, problem-solving abilities in mathematics are crucial. (Laia & Harefa, 2021) also argues that mathematical problem-solvers will be able to keep up with the demands of their life, become more productive professionals, and comprehend the complexities of global civilization in the twenty-first century. Therefore, the capacity of students to solve mathematical issues must be regularly honed for them to solve the current difficulties.

Problem-based learning is very important in improving the national education system in Indonesia (Fajrin, 2009). The importance of problem-based learning is in line with what was conveyed by (Khusaeri, 2022) that problem-based learning is very important in order to improve students' higher-order thinking skills so that they can increase student activity and learning outcomes. Problem-based learning is very important in learning because the malasah-based learning model encourages students to be actively involved in learning activities to construct their knowledge based on the problems given by the educator/teacher (Arifin et al., 2021).

According to the findings of the 2015 PISA study (OECD, 2016) Indonesia is placed 62nd out of 70 participating nations, with an average mathematical ability score of 386. This score is lower than the global average of 490. PISA questions consist of six degrees of difficulty (level 1 is the lowest and level 6 is the highest). At a high level, Indonesian students only achieved 0.8% in answering questions, with an average international achievement of 15.3%. For low-level questions, Indonesian students achieved 42.3% in answering questions, with an average international achievement of 13.0%. This indicates that Indonesian students have a limited capacity to solve problems at levels 5 and 6.

On a national scale, the average score for the National Mathematics Examination (UN) in Indonesia is still not satisfactory. In 2019, the average score for the SMP/MTs national exams was 45.52. In 2018, the average value of the national junior high school/MTs mathematics exam decreased by 6.97 points from the previous year, which was 50.31 to 43.34, and the value of mathematics subjects was the lowest value of all the subjects tested. The value of mathematics subjects is also the lowest value of all the subjects tested (Kemendikbud, 2019). On the district/city scale, the average score of the 2019 SMP/MTs math national exam in Pekanbaru City was 51.97. In 2018 the average value of the SMP/MTs Mathematics National Examination decreased by 3.62 points. In 2017, the average national test score was 50.38, however in 2018, it dropped to 46.76 (Kemendikbud, 2019).

In this study, researchers investigated mathematical problem-solving ability in one of Riau Province's SMP/MTs., especially in Pekanbaru City, namely SMP Negeri 32 Pekanbaru. 2019 National Examination average score (UN) in mathematics at SMP Negeri 32 Pekanbaru is 55.33.

Given that since 2016 BSNP has integrated contextual problem-based questions into the National Examination (BSNP, 2016), the mathematics problem-solving skills of SMP Negeri 32 Pekanbaru students must be enhanced.

To respond to this, the researchers gave the KPMM test to class VII students of SMP Negeri 32 Pekanbaru, totaling 40 students, so that the results of extracting information became more accurate. Based on the test results, KPMM has not been achieved optimally. The researcher gave the KPMM test on social arithmetic material. The test results are shown in Table 1 below.

**Table 1.** KPMM Pre-Test Results

No.	Indicator	Number of Students	Percentage	Category
1	Understanding the problem	3	7.5%	low
2	Planning problem solving	1	2.5 %	low
3	Implementing a problem-solving plan	7	17.5%	low
4	Interpret the results obtained	1	2.5%	low

Based on Table 1, it is evident that all student KPMM indicators continue to be in the bad group. In the indicator of understanding the problem, some students just copy the questions without understanding what is known and asked from the questions given, and many are directly working on the questions. On the planned problem-solving indication, all students do not comprehend transforming the problem's narrative into a mathematical model. In the indicator of implementing a problem-solving plan, namely solving problems correctly, completely, and systematically, seven students who meet these indicators prioritize mathematical calculations rather than identifying problems and making mathematical models. Not all students who fulfill the indications of problem comprehension also meet the indicators of problem-solving plan implementation. Many students cannot answer the problem from the questions given because Some students bypass the stages of problem analysis and problem-solving planning. In the final indication, interpreting the results obtained, students did not write conclusions from the answers obtained, and some wrote conclusions that were not correct because the answers were not correct.

Based on the findings of the administered problem-solving test, to overcome the problem-solving ability problem above, a learning model prioritizes the activeness of students so that students may enhance their ability to solve mathematical problems. The problem of learning mathematics found by researchers and must be improved is how to teach students to be able to use mathematical concepts they already have to solve a non-routine problem, familiarize students with interacting with each other to build critical ideas in analyzing problems, and build students' communication skills. Students stimulate their development in expressing logical opinions to provide alternative problem-solving. One of the appropriate learning models to be applied in improving students' KPMM is the Problem Based Learning (PBL) model (Syamsyiah et al., 2022).

The PBL model has enormous potential to make learning experiences more interesting and meaningful (Bakti & Santoso, 2021). In addition, PBL also facilitates students to investigate and solve problems and is student-centered (Kusumawati et al., 2022). Students will enter into

a competition with their group, and each group competes to be the most superior among the others (Ndolu & Tari, 2020). Simultaneously, doing tasks, attempting something new, and making them feel important to make students happy (Nisa & Muhtar, 2022).

PBL is learning in which students address a real-world problem as their starting point and guiding them to be able to solve or solve the problem through activities or learning experiences carried out during the learning process (Isrok'atun & Rosmala, 2018). According to (Isrok'atun & Rosmala, 2018) students can be trained to give opinions or ideas in problem-solving through learning activities using the PBL model. PBL-based mathematics education gives students with opportunity to explore their talents and generate problem-solving strategies. (Devi & Bayu, 2020).

This research was based on the social mathematics material presented in the even semester of the 2019–2020 academic year. This content relates to KD 3.9 Identifying and assessing diverse social arithmetic scenarios and KD 4.9 Solving social arithmetic issues (sales, purchases, discount, profit, loss, single interest, percentage, gross, net, tare). Social arithmetic is one of the most essential subjects for students to master (Dila & Zanthly, 2020; Nuraeni et al., 2020; Sari & Rahayu, 2018). Social arithmetic is a part of mathematics that discusses the calculations used by people in everyday life problems (Aziz & Hidayati, 2022; Inayah, 2018). This is done because students have trouble addressing social arithmetic problems (Bela et al., 2021; Yunia & Zanthly, 2020). This is evident from the results of the first exam given to students, the majority of whom were unable to answer the questions.

Research related to this research is like research conducted by (Nasir, 2016) where in this study also discusses the effectiveness of using the BPL model on problem solving abilities in fractional material, research results shows that there is a significant increase in students' problem-solving abilities between the use of the learning model problem-based (PBL) with the conventional model. Difference This increase is seen from the average value of the increase in the experimental class applied by the PBL model is 22.81, more than greater than the average value in the control class applied by the conventional model, which is 8.45. Furthermore, research conducted by (Sapoetra & Hardini, 2020) on the effectiveness of PBL in terms of problem solving abilities, the results of this study indicate that the Problem Based Learning model is more effective than the direct learning model in terms of students' mathematical problem solving abilities. The difference between previous research and this research is that the material taught is different, in this study the researcher uses or teaches material about social arithmetic to junior high school students.

This study is a sort of quasi-experimental research (quasi-experimental) that aims to find the rise in students' KPMM due to the implementation of the Problem-Based Learning model. This research will include two sets of classes: the experimental class, in which students are taught using the Problem-Based Learning model, and the control class, in which students are taught using the conventional.

### **Research Methods**

The population in this study were all seventh grade students of SMP Negeri 32 Pekanbaru for the 2019/2020 academic year which consisted of five classes, namely VII<sub>1</sub>, VII<sub>2</sub>, VII<sub>3</sub>, VII<sub>4</sub>, and VII<sub>5</sub> with a total of 179 students. The sample in this study was class VII<sub>1</sub> as many as 35 students who became the control class and class VII<sub>3</sub> as many as 35 students became the experimental

class. As shown in Table 2, the quasi-experimental design used in this investigation is the Nonequivalent Pretest-Posttest Control Group Design.

**Table 2.** The Nonequivalent Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experiment	O	X	O
Control	O	–	O

Source: (Lestari & Yudhanegara, 2018)

The initial mathematical ability (KAM) scores of the five population classes were tested for normality and homogeneity to determine the sample class for this investigation. KAM data for population class students was obtained from the results of daily tests on the comparison material of worth and inverse values. After obtaining the KAM score classes that are normally distributed and homogeneous, then a draw is conducted to determine the two classes that will be used as research samples. To ensure the equality of abilities of the two classes that have been taken at random, a test of the average equivalence of the sample class KAM data is carried out. From the test results, Class VII<sub>1</sub> was selected as the control class, whereas class VII<sub>3</sub> was selected as the experimental class.

To analyze the increase in the KPMM of students before and after being given treatment, N-gain data was used. The N-gain data or normalized gain is derived by comparing the difference between posttest and pretest scores to the difference in the SMI (ideal maximum score). The N-gain value is determined using the following formula.

$$N - gain = \frac{skor\ posttest - skor\ pretest}{SMI - skor\ pretest} \quad (1)$$

On the N-gain data (henceforth referred to as the KPMM increase score), the experimental and control groups' KPMM increases will be compared using hypothesis testing to see if there is a significant difference. The similarity test of two means, which is preceded by the normality test and the homogeneity test of variance, is used in the hypothesis test.

## Result and Discussions

### *Data Analysis of Early Mathematical Ability (KAM)*

The analysis was carried out using inferential data analysis. The data will go through the normality test process, homogeneity of variance, and continued with the similarity test of the two averages. This test uses SPSS software version 23 for windows. Based on the test results from the five population classes, only KAM data for students in grades VIII<sub>1</sub> and VII<sub>3</sub> were normally distributed and had homogeneous variances. The researcher also conducted a two-mean similarity test on the KAM data of the two classes to ensure the equality of the KAM scores for the sample classes. The standard test is the t-test. This is the formulation of the hypothesis:

H<sub>0</sub>: There is no difference between the mean KAM scores of the two classes.

H<sub>1</sub>: There is a discrepancy in the mean KAM scores of the two classes.

Using SPSS version 23 for Windows and the Independent Sample T-Test, the following are the results of a similarity test comparing the two average KAM scores of the sample classes.

**Table 3.** The results of the Similarity Test of Two Average Student KAM Data

Class	N	Mean	St. Deviasi	Nilai t	Sig. (2 tailed)	Description
VII <sub>1</sub>	40	72.58	15.638	0.214	0.831	H <sub>0</sub> Accepted
VII <sub>3</sub>	39	71.85	14.541			

The significance value (sig.) is more than  $\alpha=0.05$ , hence H<sub>0</sub> is acceptable, as shown in Table 3. In other words, with a 95% level of confidence, it was determined that the average KAM of students in grades VII<sub>1</sub> and VII<sub>3</sub> was identical. In addition, researchers selected class VII<sub>1</sub> as the control group and class VII<sub>3</sub> as the experimental group.

*KPMM (Mathematical Problem-Solving Ability) Improvement Data Analysis*

The researcher compared the average KPMM improvement score (N-Gain) of experimental and control class students to assess the difference in KPMM improvement quality between the students of the two courses. Before conducting the test, the two sample classes were subjected to a normality test and a homogeneity test of the variance of the KPMM (N-Gain) increase score data. The normality test of the data with the Liliefors test and the homogeneity of variance test with the Levene test revealed that the higher KPMM scores of students in both courses were normally distributed and homogenous. Using the two-average similarity test on the N-Gain scores of the two sample classes, the study hypothesis was examined. This is the formulation of the hypothesis:

H<sub>0</sub>: The average KPMM improvement score in the experimental group is smaller than or equal to the average KPMM improvement score in the control group.

H<sub>1</sub>: The average KPMM improvement score in the experimental group is greater than the average KPMM improvement score in the control group.

The results of the similarity test of the two average KPMM score data for experimental and control class students using SPSS version 23 for Windows are shown in Table 4.

**Table 4.** The Results of the Similarity Test of Two Average N-Gain Scores

Class	N	Mean	St. Deviation	Score t	Sig. (2 tailed)	Description
Control	35	0.22	0.15587	-11.804	0	H <sub>0</sub> Rejected
Experiment	35	0.708	0.18849			

The significance value (sig.) in table 4 is 0.000. because the number sig. obtained from SPSS is sig. 2-way (two-tailed), if  $\frac{1}{2} sig. (2 - way) = sig. (1 - way) > 0.05$ . H<sub>0</sub> is rejected if H<sub>0</sub>

is approved in that circumstance. Students in the experimental class fared better on the KPMM increase, on average, than students in the control group, with a 95% level of confidence. This reveals that students who participate in courses employing the PBL paradigm showed a greater rise in KPMM than those who engage in conventional learning.

### *Discussions*

In the experimental class, the PBL model is used to facilitate the learning process, and at each meeting, each student receives a Student Worksheet (LKPD) that directs them to answer problems using the PBL model and KPMM phases. The PBL approach used in the experimental class encourages students to actively solve mathematics problems offered in the LKPD in groups as part of the learning process. In the control class, students got all materials straight from the teacher. In the control class, students got all materials straight from the teacher. As for the learning process in the experimental class and control class can be seen in the picture below.



**Figure 1.** The learning process in the experimental class



**Figure 2.** The learning process in the control class

At the student introduction to difficulties level, students have the chance to comprehend the challenges provided in the LKPD. At the stage of organizing students to learn, students are

encouraged to ask questions about things that are not understood about the given problem and are asked to identify what is known and asked about the problems that exist in the LKPD. Furthermore, in the third stage, which is known as leading individual and group investigations, students are instructed to gather data in order to answer difficulties about the LKPD through group discussion. Students then associate the data that has been collected to solve problems on the LKPD. After students solve the problem,

Students are required to produce a conclusion on the problem-solving process. Next, the teacher invites students to report the outcomes of their group work in front of the class, both verbally and in writing, about the topic being studied. This phase is known as the work's development and presentation. In the last phase, the instructor facilitates students' collaborative reactions to the findings of other groups' presentations. The teacher conducts questions and answers to confirm, provide additional information, or complete student information. All of these PBL procedures make explicit the responsibilities of instructors and students and encourage active student participation in order to build mathematical problem-solving ability. This is in accordance with the statement (Kodariyati & Astuti, 2016) that PBL can facilitate better problem-solving, group work, and interpersonal skills.

Learning using the PBL model trains students to make designs and processes that lead to problem-solving, thus building their own knowledge through real experience. Then students identify problems by looking for things that are known, asked, and looking for ways to solve problems suitable for solving this problem. In investigating and solving problems, in the process, students use many skills so that they are motivated to solve problems, and the teacher appreciates the activities of students so that students enjoy working together.

In the experimental class, the PBL model can optimize the active participation of students with discussion in groups to solve the problems given. Optimizing this participation causes increased student activity in learning and requires higher thinking skills so that students can feel the benefits of learning mathematics because the problems solved are everyday problems. In addition, with the application of the PBL model that presents problems as a focus for learning, students can be trained to solve problems. The stages of the PBL model significantly aid students in improving their mathematical problem-solving abilities, allowing them to enhance their mathematical problem-solving skills in relation to the subject matter they are studying.

The findings of this study are consistent with those of other studies (Sumartini, 2016) which students who are taught using the PBL model demonstrate more KPMM improvement than students who are taught using conventional learning methods. The results of the study (Yusri, 2018) also reveal that The PBL model has a positive effect on students' KPMM because, while using the PBL model, students better comprehend difficulties, plan problems, solve problems according to their plans, and interpret solutions.

The answers of students in the experimental class who took part in learning with the PBL model still contained several errors. The error is a principle error. Namely, students determine the purchase price after the discount, not by reducing the purchase price before the discount with a large discount, as shown in Figure 1 below.

diskon =  $10\% \times 2.744.000$  (2)

$$\frac{10}{100} \times 2.744.000$$

$$= 274.400$$

Jadi Pak rayhan harus membayar  
274.400 (1)

**Figure 3.** Example of student error 1

Because the PBL model requires students to better grasp issues, create solutions to difficulties, carry them out according to plans, and analyze results, its adoption has a beneficial impact on students' KPMM. Another student error is an error in interpreting the results obtained, because of the student's conceptual error, namely students assume that the overall selling price is an advantage, so students are less precise in interpreting the results obtained. The students' errors are shown as follows.

Hj:  $20000 \times 40$      $ra: 34 \text{ buah}$

$$= 800.000$$

Hj:  $28.000 \times 34$      $ra: 18.000$      $Hj: 18000 \times 6$

$$= Rp 952.000$$

$$ra: 6$$
     $= 108.000$ 

Hj:  $Hj + Hj = 852.000 + 108.000$

$$= 960.000$$

Jadi, Triana mengalami keuntungan  
Sebesar Rp. 160.000 (1)

**Figure 4.** Example of student error 2

The next error is that students do not pay attention to the instructions about the questions properly, namely students do not write down what is known and what is asked, students are also wrong in making mathematical models, namely  $5x = 165000$  should be 5 multiplied by 165000 equals 825000, causing errors in drawing conclusions. This can be seen from the image below.

$$5x = 165.000$$

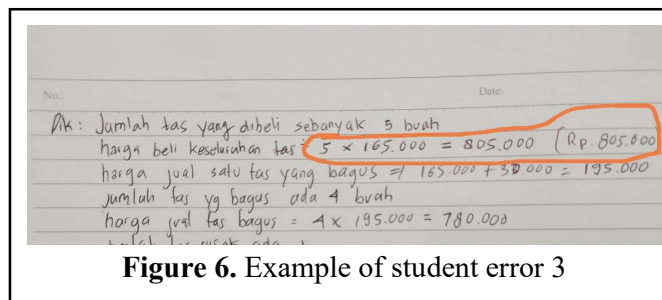
$$x = \frac{165.000}{5}$$

$$x = 33.000$$

Kemudian x dijual dengan harga Rp. 30.000 lebih tinggi, menjadi 63.000  
jadi bi rahma mengalami keuntungan.

**Figure 5.** Example of student error 3

The other error is a calculation error, which also causes errors in drawing conclusions, on the student answer sheet it can be seen that the student multiplied 5 times 165000 where the actual result was 825000 instead of 805000, even though the student had made what was known on the answer sheet, this can be seen in the image below.



**Figure 6.** Example of student error 3

By assessing the N-Gain score, researchers assessed the rise in KPMM across students. Using the SPSS tool and t-test, the N-Gain scores of students were evaluated. The significance value (sig) determined by the findings of the analysis is 0.000. This demonstrates that H0 is rejected and H1 is approved, indicating that the growth in KPMM of students who participate in learning via the application of the PBL model is superior to that of students who participate in conventional learning. In terms of the sample class's average KPMM increase score, the experimental class has a score of 0.7080, while the control class has a score of 0.2200.

Despite the fact that the adoption of the PBL model in this research helped the enhancement of students' KPMM, this study had flaws. One of the limitations of this research is that, according to the findings of the KPMM test administered after treatment (posttest), the proportion of experimental class students who record each KPMM step in problem-solving is not ideal. Nevertheless, as compared to the control class, the experimental class had a greater number of students on each KPMM indicator. This finding confirms the results of hypothesis testing, which indicate that the growth in KPMM of students who participate in learning via the application of the PBL model is greater than that of students who engage in conventional learning.

On the basis of the number of students in the experimental class, it can be concluded that the ability of poor students in mathematical problem-solving indicators is the capacity to execute problem-solving strategies. At this point, students must compose thorough and accurate responses. According to the answer sheet, a few students have not typed their answers accurately and entirely. Students are not completely capable of determining answers to the provided difficulties. In addition to the capacity to execute problem-solving strategies, the stage of comprehending the acquired outcomes is also quite low. Many students did not write the conclusion at the end of the problem-solving exercise, while others who did write it did so imperfectly since the solution was incorrect.

### **Conclusion**

On the basis of the framing of the issue, the preceding chapter's research and discussion findings may be summarized as follows: Students in class VII at SMP Negeri 32 Pekanbaru who participate in learning via the implementation of the Problem Based Learning (PBL) model are better able to solve mathematical problems than students who participate in conventional

learning. The Problem Based Learning (PBL) model is an excellent alternative learning model used by mathematics instructors because it actively engages students in the process of developing their mathematical problem-solving abilities throughout each class. Teachers/researchers who want to investigate students' mathematical problem-solving skills must highlight to students the need of documenting each stage of mathematical problem-solving in detail. This may be included in the daily test instructions and confirmed verbally.

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