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# The effect of the Missouri Mathematics Project (MMP) and Problem-Based Learning (PBL) on junior high school students' understanding of mathematical concepts

Annisa Desti Fahjri [a,1,*], Wahyudin [a,2], Siti Fatimah [a,3]

[a] Universitas Pendidikan Indonesia, Bandung, Jawa Barat, Indonesia
[1] annisadestifahjri@upi.edu*; [2] wahyudin.mat@upi.edu; [3] sitifatimah@upi.edu
* corresponding author

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ABSTRACT

One contributing factor to students' low understanding of mathematical concepts is their tendency to focus on procedures rather than concepts. This study aims to compare the effectiveness of the Missouri Mathematics Project (MMP) and Problem-Based Learning (PBL) models in enhancing junior high school students' conceptual understanding in mathematics. This quasi-experimental study used a non-equivalent pretest-posttest control group design involving two 7th-grade classes from a junior high school in Banjarmasin. Class VII A used the MMP model, while Class VII B used the PBL model. Students' understanding was measured using pretest and posttest assessments on ratio and comparison material, and the data were analyzed using SPSS. The results showed that the MMP group had a higher average gain score (0.8741) than the PBL group (0.4722). However, the Independent Samples Test revealed a significant difference ($p < 0.001$), indicating that both models significantly improved students' understanding, with PBL showing greater statistical effectiveness. This suggests that although MMP yielded a higher mean gain, the consistent effectiveness of PBL across students makes it more effective in practice. These findings suggest that both MMP and PBL can be applied to strengthen students' conceptual understanding. Teachers are encouraged to integrate contextual, student-centered strategies such as those in PBL to better support conceptual development in mathematics classrooms.



## 1. Introduction

Understanding mathematical concepts is a critical component of students' mathematical competence. Conceptual understanding enables learners to explain mathematical ideas, connect different representations, and apply knowledge in novel situations. The Programme for International Student Assessment (PISA), conducted by the Organisation for Economic Co-operation and Development (OECD), uses indicators of conceptual understanding to measure students' ability to use mathematical reasoning and apply mathematics in real-world contexts. This reflects a global shift in mathematics education from procedural mastery alone toward deeper, meaningful understanding. In the Indonesian context, the ability to understand mathematical concepts among junior high school students remains an ongoing challenge. According to the results of PISA 2018, Indonesian students ranked below the OECD average in mathematics, particularly in tasks requiring conceptual reasoning and problem-solving. This result aligns with the findings of Kartika, who observed that many students struggle to restate mathematical concepts in their own words or represent them symbolically [1]. Fajar et al., similarly found that students perceive mathematics as abstract and difficult, which leads to low motivation and shallow learning strategies [2]. Radiusman emphasizes that mathematics learning oriented toward mathematical literacy can help students construct their own knowledge, thereby enhancing conceptual understanding. Several factors contribute to this condition [3]. One of the most significant is the continued reliance on teacher-centered learning models that emphasize rote memorization and algorithmic procedures rather than active engagement with concepts. As a result, students often develop superficial knowledge that fails to transfer to real-world problems or unfamiliar situations. These patterns suggest the need for more effective instructional models that actively involve students in constructing meaning, engaging with problems, and developing a solid understanding of mathematical concepts.

One such model is the Missouri Mathematics Project (MMP). This model focuses on intensive learning through a structured, repetitive cycle involving direct instruction, guided practice, group discussion, and application. Ervinasari & Astuti highlighted that MMP helps students to gradually build mathematical understanding through the process of individual learning followed by collaborative reinforcement [4]. Sofyan found that the application of the MMP learning model significantly improved students' ability to solve mathematical problems, which is closely linked to the development of conceptual understanding [5]. Muzhaffar also found that the use of MMP significantly improved students' critical thinking skills in high school mathematics [6]. Furthermore, Fadli et al., showed that students taught through the MMP model achieved better learning outcomes compared to those taught with conventional methods [7]. Rodliyah et al., found that integrating MMP into a learning module contributed positively to students' mathematical literacy development [8]. Similarly, Setyowati & Nurcahyo emphasized that the MMP model not only improved students' literacy skills but also strengthened their mathematical self-efficacy [9].

In contrast, Problem-Based Learning (PBL) offers a more open-ended and exploratory learning environment. Students are introduced to complex, real-life problems that they must explore, analyze, and solve using mathematical concepts. The PBL approach encourages students to take ownership of their learning, collaborate in groups, and engage in inquiry-driven problem-solving. Adnang et al., emphasized that PBL promotes student activity and higher-order thinking [10], while Kusumawati et al., found that PBL enhances students' independence and contextual understanding of mathematics [11]. Recent international studies reinforce the effectiveness of these models in improving conceptual understanding. Yohannes et al., conducted a meta-analysis and concluded that PBL significantly improves students' mathematical critical thinking skills and conceptual learning, reporting a large effect size across studies [12]. Rahmadhani et al., found that implementing PBL in a lesson study framework increased students' activeness and conceptual mastery within two learning cycles [13]. Gee, E., & Harefa, D. also found that the MMP model effectively improves students' mathematical problem-solving skills because it facilitates active learning through structured and repeated exposure to mathematical concepts [14]. Similarly, Handayani et al., reported that MMP had a positive impact on students' mathematical problem-solving ability, indicating its potential to be applied successfully in various educational contexts [15].

Despite these findings, previous studies tend to focus on either MMP or PBL individually. There is a notable lack of comparative studies that explore the differences in effectiveness between the two models, especially in junior high school settings within Indonesia. Moreover, many studies have not explicitly examined whether a higher average learning gain (as often found in structured models like MMP) actually correlates with greater consistency or statistical significance in learning outcomes, as might be expected from more collaborative models like PBL. Therefore, this study aims to analyze and describe the influence of MMP and PBL on the acquisition and improvement of students' mathematical concept understanding abilities, which will be tested using SPSS.

## 2. Method

### 2.1. Types of Research

This study uses a quantitative approach with experimental methods. Initially, the research appeared to apply a One Group Pretest-Posttest and Pretest-Posttest Control Group Design, which are described below this. One Group Pretest-Posttest Design, which can be described in the following Table 1. Based on several types of experimental research methods mentioned above, the one used in this study is Quasi Experimental Design in the form of Pretest-Posttest Control Group Design can be seen in Table 1.

**Table 1.** One group pretest-posttest design

| Pretest | Treatment | Posttest |
|---|---|---|
| $O$ | $X$ | $O$ |

In this study, $O_1$ refers to the initial test (pretest) administered to both the experimental and control classes before the implementation of the learning model. The symbol X represents the treatment, namely the application of the learning model provided specifically to the experimental class. Meanwhile, $O_2$ denotes the final test (posttest) conducted for both the experimental and control classes after the learning model had been implemented. Pretest-Posttest Control Group Design, which can depicted in the following Table 2.

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

| Pretest | Treatment | Posttest |
|---|---|---|
| $O_1$ | $X_1$ | $O_2$ |
| $O_3$ | $X_2$ | $O_4$ |

In this study, $O_1$ refers to the initial test (pretest) administered to the experimental class before receiving treatment, while $O_2$ denotes the final test (posttest) conducted after the treatment. Similarly, $O_3$ represents the initial test for the control class before treatment, and $O_4$ indicates the final test after the treatment. The treatments given consisted of two types: $X_1$, which refers to the application of the MMP learning model in the experimental class, and $X_2$, which refers to the application of the PBL learning model in the control class. This study utilized a non-equivalent control group quasi-experimental design with pre-test and post-test to compare the impact of two instructional models—Missouri Mathematics Project (MMP) and Problem-Based Learning (PBL)—on students' conceptual understanding of mathematics, particularly in conditions where random assignment was not feasible. This design allows researchers to maintain control over internal validity while observing the effects of different teaching strategies on student outcomes. The selection of this approach is supported by international studies. For instance, Nkosi & Motlhabane demonstrated that inquiry-based learning significantly enhanced learners' conceptual understanding of chemical change compared to traditional methods using a quasi-experimental pre-post design [16]. Similarly, a comprehensive meta-analysis by Freeman et al., concluded that active learning strategies, which align with models like PBL, resulted in higher performance and lower failure rates in STEM education than traditional lecture methods [17]. In another quasi-experimental study, Oribhabor et al., reported that the application of activity-based teaching methods significantly improved mathematics achievement among secondary school students in Nigeria [18]. Furthermore, Jatisunda et al., found that project-based learning significantly enhanced mathematical problem-solving abilities among vocational high school students, as shown through a pre-test/post-test control group design [19]. These findings confirm the feasibility and strength of quasi-experimental methods for comparing instructional approaches like MMP and PBL, even when true randomization is not achievable.

## 2.2. Sample and Population

The population in this study consisted of all seventh-grade students in one of the junior high schools in Banjarmasin. The sample was selected using purposive sampling, considering the accessibility and characteristics relevant to the research objectives. This technique was chosen to ensure that the selected classes had similar academic backgrounds and learning conditions prior to the intervention. Two classes were selected as the research sample: one as the experimental class taught using the Missouri Mathematics Project (MMP) learning model, and the other as the control class taught using the Problem-Based Learning (PBL) model. Purposive sampling was deemed appropriate due to school policy and schedule constraints that made random sampling infeasible. Both classes were taught by the same teacher to minimize teacher-related bias. Moreover, efforts were made to ensure that the learning materials, classroom facilities, and teaching time allocation remained equivalent across the two groups, maintaining the internal validity of the experiment.

## 3. Research Result

This study aims to analyze and describe the influence of MMP and PBL on the acquisition and improvement of students' conceptual understanding in mathematics at a junior high school in Banjarmasin City.

### 3.1. Students' acquisition of mathematical concept understanding

The results of descriptive analysis of posttest or acquisition data are used to describe the development of mathematical literacy of students who received both MMP and PBL learning can be seen in Table 3.

**Table 3.** Descriptive analysis of students' mathematical concept understanding from MMP and PBL posttest data

| Analysis Descriptive | MMP Model | PBL Model |
|---|---|---|
| Mean | 18,26 | 12,41 |
| Standart Deviation | 1,583 | 3,029 |

The output above shows that the average score for mathematical concept understanding of students who learn with the MMP model is higher (18.26) compared to students who learn with the PBL model (12.41). The influence of MMP learning on students' Mathematical Concept Understanding Ability depends on whether the hypothesis stating: "MMP has a significant influence on students' Mathematical Concept Understanding Ability" is rejected or accepted, which formally, the statistical hypothesis ( $H_0$) and the research hypothesis ( $H_1$) are as follows:

$$H_0: \mu_1 = \mu_2 \tag{1}$$

$$H_1: \mu_1 \neq \mu_2 \tag{2}$$

In this study, $\mu_1$ represents the mathematical concept understanding ability of the student population who acquired it through the MMP learning model, while $\mu_2$ refers to the mathematical concept understanding ability of the student population who acquired it through the PBL learning model. To test the hypothesis above, SPSS software related to the Paired Sample T-Test was used and the following output was obtained can be seen in Table 4.

**Table 4.** Paired Samples Test

| | Significance Two-Side p |
|---|---|
| Pretest MMP-Posttest MMP | <0,001 |

From *the* Paired Sample Test*, it turns out that the* Two-Side Significance *p* value was obtained his $< 0{,}001$and this value is less than 0.05 ( $\alpha$) so $H_0$it is rejected then $H_1$ accepted which means that MMP has a significant influence on students' Mathematical Concept Understanding Ability. Then the paired sample effect sizes can be presented in Table 5.

**Table 5.** Paired Samples Effect Sizes

| | | Point Estimate |
|---|---|---|
| Pretest MMP-Posttest MMP | Cohen'sd | -6,451 |

From Paired Sample Effect Sizes it turns out mark Point Estimate his more small from 0.2 (Cohen'sd category) which means that the influence of the MMP learning model on acquisition Ability Understanding Draft Mathematical student is in the category low. Almost the same with the MMP model where the question related with influence PBL learning towards Ability Understanding Draft Mathematical student depend on being rejected or received hypothesis which states: "PBL has an effect in a way significant to acquisition Ability Understanding Draft Mathematical students" which formally, hypothesis statistics ( $H_0$) and the research hypothesis ( $H_1$) are as follows:

$$H_0: \mu_1 = \mu_2 \tag{3}$$

$$H_1: \mu_1 \neq \mu_2 \tag{4}$$

The symbol $\mu_1$ refers to the mathematical concept understanding abilities acquired by the student population who learned through the MMP learning model, while $\mu_2$ denotes the mathematical concept understanding abilities acquired by the student population who learned through the PBL learning model. To test the hypothesis above, SPSS software related to the Paired Sample T-Test was used and the following output was obtained can be seen in Table 6.

**Table 6.** Paired Samples Test

| | Significance Two-Side p |
|---|---|
| Pretest PBL-Posttest PBL | <0,001 |

From Paired Sample Test it turns out obtained mark Significance of Two-Side $p$ his $< 0{,}001$ and this value is smaller than 0.05 ($\alpha$) so $H_0$ it is rejected, which means that PBL has a significant influence on the acquisition of skills understanding draft mathematical student. Then the effect size of the paired samples can be presented as in Table 7.

**Table 7.** Paired Samples Effect Sizes

| | | Point Estimate |
|---|---|---|
| Pretest PBL-Posttest PBL | Cohen'sd | -2.929 |

From Paired Sample Effect Sizes it turns out mark Point Estimate his more small from 0.2 (Cohen'sd category) which means that the influence of the PBL learning model on acquisition Ability Understanding Draft Mathematical student is in the category low. Now we will determine whether there is a difference in the influence of MMP and PBL on students' acquisition of mathematical conceptual understanding. This decision depends on whether the hypothesis "there is a difference in the influence of MMP and PBL on students' acquisition of mathematical concept understanding ability" is rejected or accepted, which can be formally written as follows:

$$H_0: \mu_1 = \mu_2 \tag{5}$$

$$H_1: \mu_1 \neq \mu_2 \tag{6}$$

In this research, $\mu_1$ is defined as the mathematical concept understanding ability of the student population who obtained it through the MMP learning model, whereas $\mu_2$ is defined as the mathematical concept understanding ability of the student population who obtained it through the PBL learning model. By using SPSS, the following statistical data was obtained can be seen in Table 8.

**Table 8.** Independent Samples Test

| | Significance Two-Side p |
|---|---|
| Posttest_MMP_PBL | <0,001 |

The Independent Samples Test showed that the two-tailed significance (p-value) was less than 0.001, which is smaller than 0.05 ($\alpha$). This indicates that $\boldsymbol{H_0}$is rejected, meaning that there is a significant difference between the effects of MMP and PBL on students' mathematical conceptual understanding. Followed by the independent sample effect sizes presented in Table 9.

**Table 9.** Independent Samples Effect Sizes

| | | Point Estimate |
|---|---|---|
| Posttest_MMP_PBL | Cohen'sd | 2.417 |

The Independent Samples Effect Sizes analysis showed a Point Estimate of 2.417, which is greater than 0.2 (Cohen'sd category), falling into the medium category. This indicates a significant difference in the effect on students' acquisition of mathematical conceptual understanding, even though it falls within the medium category.

### 3.2. Improving students' understanding of mathematical concepts

We will examine the improvement of students' understanding of mathematical concepts who learn with MMP and students who learn with PBL. To do that, we need gain score data and SPPS assistance so that statistical data is obtained as presented in Table 10.

**Table 10.** Descriptive analysis of the increase in students' understanding of mathematical concepts from MMP and PBL posttest data.

| Analisis Deskriptif | Model MMP | Model PBL |
|---|---|---|
| Mean | 0,8741 | 0,4722 |
| Standar Deviasi | 0,11755 | 0,19624 |

The results of Table 10 above show that the average score for increasing understanding of mathematical concepts of students who learn with the MMP model is higher (0.8741) compared to students who learn with the PBL model (0.4722). The purpose of this analysis is to compare the data on students' mathematical concept understanding ability scores using MMP and PBL to determine whether there is a difference in the influence between MMP and PBL in improving students' mathematical literacy. To answer this research question, data on students' mathematical literacy gain scores are needed, calculated using the Hake formula and analyzed using SPSS. The conclusion will be based on the results of the hypothesis test that examines the difference in the influence between MMP and PBL learning on improving students' mathematical concept understanding ability. Hypothesis the formally can written as the following:

$$H_0 : \mu_1 = \mu_2 \tag{7}$$

$$H_1 : \mu_1 \neq \mu_2 \tag{8}$$

The parameter $\mu_1$ refers to the mathematical concept understanding abilities acquired by the student population through the MMP learning model, while $\mu_2$ refers to the mathematical concept understanding abilities acquired by the student population through the PBL learning model. By using SPSS, the following statistical data was obtained can be seen in Table 11:

**Table 11.** Independent Samples Test

| | Significance Two-Side p |
|---|---|
| NGain_MMP_PBL | <0,001 |

From the Independent Samples Test, the Two Sided Significance p value was obtained $<$ 0,001 and this value is smaller than 0.05 ($\alpha$) which means that $H_0$ it is rejected that there is a difference in the influence of MMP and PBL on improving students' mathematical concept understanding abilities. The last one is the independent sample effect size which can be seen in Table 12.

**Table 12.** Independent Samples Effect Sizes

| | | Point Estimate |
|---|---|---|
| NGain_MMP_PBL | Cohen'sd | 2.484 |

From the Independent Samples Effect Sizes, the Point Estimate value was obtained as 2.484, which means it is greater than 0.2 (Cohen's d category), which means that the influence of MMP and PBL learning on improvement is classified as moderate.

## 4. Discussion

Based on the explanation above, Findings from several international studies highlight that the effectiveness of learning models such as Problem-Based Learning (PBL) and Inquiry-Based Learning (IBL) is significantly influenced by student characteristics, learning motivation, and implementation context. Nurlaili, Zurweni & Syaiful found that the integration of inquiry and PBL models significantly enhanced students' conceptual understanding of mathematics, especially when student motivation was high [20]. This suggests that internal factors, such as student engagement and readiness, play a crucial role in the success of innovative learning approaches like PBL. Khasawneh et al., compared the effectiveness of inquiry-based instruction with traditional lecture methods in college algebra courses [21]. Their findings revealed that inquiry-based learning was considerably more effective in improving student achievement, as it encouraged active participation and deeper cognitive engagement with mathematical concepts. Dwianty also reported that the inquiry approach positively impacted secondary students' mathematics performance, particularly in fostering critical and analytical thinking skills necessary for understanding abstract mathematical ideas [22]. Furthermore, Zhou et al., found that integrating project-based and inquiry-based approaches significantly improved critical thinking and teamwork skills among fourth-grade students in mathematics learning [23]. Although models like PBL and IBL require more time and strategic planning, they provide long-term benefits for students' conceptual mastery and development of essential soft skills. Therefore, implementation of models such as PBL, inquiry, and MMP should align with student readiness and instructional goals to optimize their educational potential.

Based on the explanation above, it is evident that the MMP model positively impacts student learning outcomes in understanding mathematical concepts. This aligns with the theory proposed by Ervinasari & Astuti, stating that MMP is designed with structured exercises and group discussions that gradually enhance student understanding [4]. MMP engages students not only in passive material reception but also in solving problems individually and in groups, thereby creating an in-depth learning experience. On the other hand, while PBL also showed improvement, its value was lower than MMP. This could be attributed to PBL's characteristic of emphasizing open problem solving, which may confuse some students if they are not accustomed to it. Although PBL promotes independence and collaboration[11], its effectiveness in boosting immediate achievement scores may be slower compared to the more structured MMP. From the analysis of improvement data, the average N-Gain of students taught with MMP was 0.87 (high category), while for the PBL model it was 0.47 (moderate category). This shows that MMP is more effective in enhancing students' understanding of mathematical concepts during the learning process. MMP's intensive practice encourages students to review and revisit material through structured activities such as project worksheets and periodic assessments. According to Arlianti, the syntax of MMP systematically includes review, concept development, controlled practice, independent work, and assignments—fostering strong conceptual understanding [24]. Meanwhile, PBL offers meaningful learning experiences through contextualized problems but requires more time to build stable conceptual understanding, especially if students are less familiar with independent learning [25]. This is consistent with Taqwa et al., who stated that while PBL can improve conceptual understanding, its effectiveness heavily depends on student readiness and the teacher's classroom management [26].

The results of statistical tests showed significant differences between the MMP and PBL models in improving students' conceptual understanding in mathematics. The effect size fell in the medium category, indicating that the MMP model was more effective in structured and consistent improvements in conceptual understanding. While PBL still contributed to improvement, it was more suitable for learning contexts that emphasized exploration, open-ended problem solving, and collaborative learning. The comparison between the Missouri Mathematics Project (MMP) and Problem-Based Learning (PBL) models in this study shows that while both have their merits, MMP yields higher effectiveness in improving students' understanding of mathematical concepts in structured classroom environments. This finding is supported by various international studies. For instance, Siska et al., demonstrated that MMP-based interactive media facilitated conceptual understanding by combining review, guided practice, and independent work [27]. These structured features of MMP provide consistency and clarity, which benefit learners with limited experience in self-directed learning environments. On the other hand, PBL has been widely praised for enhancing higher-order thinking skills, collaborative learning, and long-term retention. Ajai et al., (2020) reported that PBL had a significant positive effect on students' achievement in algebra compared to traditional methods [28]. Similarly, Hidayat et al., observed that students in large classes in Azerbaijan who were taught with PBL obtained higher academic scores and had lower failure rates than those taught through conventional strategies. Furthermore, Hamdanat et al., confirmed that PBL significantly improved Moroccan EFL students' critical thinking skills in a quasi-experimental design [29]. These findings suggest that PBL, while less structured, is highly effective when fostering analytical and reflective thinking skills.

The rigorous structure of MMP may have facilitated more consistent concept acquisition, particularly in mathematics where sequential understanding is essential. Supporting this, Freeman et al., found in their meta-analysis that active learning improves student performance and reduces failure rates across STEM disciplines, but only when combined with structured guidance [17]. In line with this, Marchy et al., emphasized that structured mathematical instruction enhances not only students' procedural fluency but also promotes deeper conceptual understanding, especially when reinforced through repeated practice and formative assessment [30]. While PBL supports long-term conceptual development and learner autonomy, its outcomes are often more variable and depend on teacher facilitation quality, class culture, and students' metacognitive maturity. Oribhabor et al., stressed the importance of classroom management and student engagement for PBL to succeed [18]. In contrast, MMP's structured sequence review, concept development, guided and independent practice offers immediate and measurable improvements in performance, especially when the goal is to reinforce conceptual clarity in mathematics. In contrast, MMP's structured sequence review, concept development, guided and independent practice offers immediate and measurable improvements in performance, especially when the goal is to reinforce conceptual clarity in mathematics.

## 5. Conclusion

Based on research that has been done can with drawn a number of conclusion, where in a way descriptive average earnings ability understanding draft mathematical students who study with the Missouri Mathematics Project (MMP) with score 18.26 more tall than the average earnings ability understanding draft mathematical students who study with Problem Based Learning (PBL). From Paired Sample Test it turns out obtained Two-Side Significance p value $<$ 0,001 and this value is less than 0.05 $(\alpha)$ which means that MMP has an effect in a way significant to acquisition Ability Understanding Draft Mathematical students. From Paired Sample Test it turns out obtained Two-Side Significance p value $<$ 0,001 and this value is less than 0.05 $(\alpha)$ which means that PBL does not influential in a way significant to acquisition Ability Understanding Draft Mathematical students. From the Independent Samples Test it was obtained mark Significance of Two Sided p his is $<$ 0,001 and this value is less than 0.05 $(\alpha)$ which means there is difference the influence of MMP and PBL on acquisition ability understanding draft mathematical student. From the answers to the statistical results questions, it turns out that descriptively the average increase is ability understanding draft mathematical students who study with Missouri Mathematics Project (MMP) with score 0.8741 more tall than the average earnings ability understanding draft mathematical students who study with Problem Based Learning (PBL). From Independent Samples Test obtained mark Significance Two-Sided p his is $<$ 0,001 and this value is less than 0.05 $(\alpha)$ which means that $H_0$it is rejected which means No there is difference the influence of MMP and PBL on improvement ability understanding draft mathematical student. The MMP learning model has an average increase in the ability to understand mathematical concepts higher than the PBL model. Although overall there are differences in the influence of MMP and PBL on improving students' ability to understand mathematical concepts.

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| | | |
|---|---|---|
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