

## **Model Problem-Based Learning for Improving Student's Mathematical Competence: Systematic Literature Review**

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### **Abstract**

Improving students' mathematical competence such as problem-solving skills, mathematical communication, reasoning, and others can use the Problem Based Learning model. This study aims to analyze the impact of the Problem Based Learning model in improving the mathematical competence of students from primary school, junior high, and senior high school levels. The research method used is Systematic Literature Review (SLR). The sample comprises 17 research results on the PBL model in improving students' mathematical competence (concept understanding, problem-solving, and communication skills). The sample comes from indexed journals from the period 2012-2019. The key research question is how PBL influences students' mathematical competence based on the year of school, level of study, research location, and sample size. The SLR method can find an increase in the number of eight-year studies. The results showed that communication skills and understanding of mathematical concepts dominated research results in improving mathematical abilities through problem-based learning models. Most of the research was conducted at the junior high school level outside Java, with a sample size of 30 people or more. Based on the results of the review, the study's conclusion proves the influence of the Problem Based Learning (PBL) model on students' mathematical competence.

**Keywords:** model problem-based learning; kompetensi matematis siswa; systematic literature review

### **INTRODUCTION**

A large number of everyday uses of mathematics is one of the reasons why mathematics is a school subject that is considered essential and studied by students at all levels of education, and mathematics is also a means of forming students to think naturally (Fitriani, 2015). Mathematics is one of the sciences that can improve the ability to think and argue, contribute to solving everyday problems and in the world of work, and provide support in the development of science and technology (Susanto, 2013). Students with high expectations can understand and apply mathematics in everyday life.

Students' mathematical competence is seen in understanding concepts, reasoning, communication, and other abilities. Understanding concepts in mathematics is a basic ability that must be possessed by students in the teaching and learning process (Susanti, Basri, & Relawati, 2019). Problem-solving ability is seen from students' ability to solve routine, non-routine, applied routine, and non-routine problems in mathematics (Eka & Ridwan, 2015). Several experts such as

Baroody, Miriam, et al stated that mathematical communication does not only convey ideas through writing, but must be broader, namely the ability of students to speak, explain, draw, ask questions and work together (Sari & Rahadi, 2014). The improvement of these three competencies will be seen by using the Problem Based Learning model.

Classical problem factors, such as the application of mathematics learning methods, are still teacher-centered, while students tend to be passive. Another classic factor is the application of conventional learning models, namely lectures, questions and answers, and giving assignments or homework (PR). (Susanto, 2013). Students' understanding and students' ability to learn because the influence of learning that is less desirable will affect students' problem-solving abilities (Juliawa, Maharani, & Rati, 2017). This is like a copy method activity, i.e., information only comes from the teacher.

Problem Based Learning (PBL) can help develop the ability to understand mathematical concepts, which can be seen from the 7 aspects contained in this model, namely: 1) clarifying terms and concepts that are not yet clear; 2) formulating problems 3) analyzing problems 4) organizing ideas systematically; 5) formulate learning objectives; 6) seek additional information from other sources; 7) synthesize (combine) and test new information and generate reports (Susanti, Basri, & Relawati, 2019). Learning activities in the classroom using a problem-based learning model give students the freedom to conduct investigations, obtain information, plan, and implement a mathematical topic in solving the problem in question (Angkotasari, 2014). Research results (Susanti, Basri, & Relawati, 2019) stated that the Problem Based Learning learning model is better for improving students' mathematical concept understanding abilities. Research conducted by (Sinaga & Manik, 2019) also stated that the use of Problem Based Learning (PBL) learning models could improve students' mathematical communication skills so that the final results of students in the experimental class are higher than the ability to solve mathematical problems in the control class. From the research results presented, researchers are interested in exploring the Problem Based Learning model in improving students' mathematical competence.

Based on the description above, the purpose of this study is to describe scientifically problem-based learning models related to mathematical competencies such as communication skills, understanding concepts, and problem-solving. The author determines the ability of these mathematical competencies to ensure and complete his research. This study determines mathematics competence based on the results of the application of PBL on mathematics competence in terms of year of study, level of study, and sample size. Thus, the data collection stage is an important stage of SLR. Through the research data collected, the researcher formulated several relevant questions as follows:

1. How is the description of the influence of PBL on improving students' mathematical competence based on the year of study?
2. How is the description of the effect of PBL on increasing students' mathematical competence based on the level of study?
3. How is the description of the effect of PBL on increasing students' mathematical competence based on the research location?

4. How is the description of the effect of PBL on increasing students' mathematical competence based on sample size?

## **RESEARCH METHOD**

### **Systematic Literature Review**

The method used is a Systematic Literature Review. The research approach is a survey-based quantitative descriptive (Littell, Corcoran, & Pillai, 2008). The survey was conducted on secondary data from primary research on Problem Based Learning models, concept understanding, problem-solving, and communication. There are three stages in this research, namely data collection, data analysis, and drawing conclusions. Sources of data from primary studies that have been published are indexed journal articles. Data collection uses indexed electronic databases such as Google Scholar, Garuda Portal, Doaj, Research Gate, and direct journal URLs. All articles were extracted to select relevant articles. All articles that have been extracted will enter the analysis stage.

### **Inclusion criteria**

The criteria for selecting the data used the inclusion criteria. Inclusion criteria are criteria for research subjects to represent research samples that qualify as samples (Notoatmodjo, 2012). The inclusion criteria that have been determined are as follows:

1. The article comes from research on mathematics education
2. The article is published in the 2012-2019 period
3. The research comes from the Problem Based Learning model in improving students' mathematical competence.
4. The sample used is research at the elementary school, junior high school, and senior high school

### **Research instrument**

The research instrument was an observation sheet or matters related to the inclusion criteria. Criteria, namely based on the year of research, level of study, sample size, and research location.

### **Population and sample**

The population of this research is all experimental research on the Problem Based Learning model in improving students' mathematical competence, including conceptual understanding, problem-solving, and communication. The number of article samples obtained was 17 relevant according to the inclusion criteria.

### **Data collection technique**

Data collection techniques in this study used articles related to the Problem Based Learning model in improving students' mathematical competence, including conceptual understanding, problem-solving, and communication. The articles found using search engine (google) as many as 25 articles using keywords "problem-based learning," "mathematics", "experiment", and "journals". After that, the next step was to select 20 articles that matched the research questions and

improved the problem-based learning model in improving mathematical competence. In the final stage, 17 specific articles were found with research questions and inclusion criteria.

## RESULTS AND DISCUSSION

This section presents the research results that have been processed by the data. Presentation of research results can use tables or graphs as a means to explain the results of the study. The research results are in line with the problems posed, so the explanation in this section can be explained through sub-sections.

The discussion is a review from the author relating to the results of the study he obtained. The basis used is previous studies, both in research and corresponding theories. Based on this, the research results can be disclosed and explained by comparing or confirming them.

There is an effect of problem-based learning on mathematics competence with various kinds of student and teacher learning activities, including mathematical communication, problem-solving, and understanding of the concepts presented in table 1.

**Table 1. Research results related to a model problem based learning for improving students mathematical competence**

Authors, Year, Vol & No, and Research Location	Level of study	Sample size	Research Result
(Tomi Utomo, dkk, 2014, 1(1), In Java)	Junior High School	> 30 students	The problem-based learning model (Problem Based Learning) has an effect on understanding the concept of class VIII SMPN 1 Sumbermalang with a significance value of 0.000 (<0.05). The average pre-test and post-test increased by 21.36 from the pre-test average of 52.45 to the post-test average of 73.81.
(Eka Yulianti dan Indra Gunawan, 2019, 02(3), outside Java Islands)	Senior High School	> 30 students	The results of data analysis using the SPSS 17.00 program show that there is an effect of applying the problem-based learning model to students' conceptual understanding and critical thinking. The gain value for understanding the concept of the experimental class is 0.51 and the gain value for the control class is 0.31 while the gain value for critical thinking in the experimental class is 0.58 and the gain value for the control class is 0.31. The effectiveness of using the PBL model is more effective in improving students' conceptual understanding and critical thinking, which is indicated by the effect size value of concept understanding of 0.36 and the critical thinking effect size value of 0.66. In addition, based on the results of the MANOVA test, both the significance value of concept understanding and the significance value are less than 0.005, so it can be concluded that there is an effect of the application of the PBL model on

				conceptual understanding and critical thinking of high school students.
(Rosalia, dkk, 2019, 7(4), outside Java Islands )	Junior High School	> 30 students		Based on the results of data analysis, it is known that the increase in understanding of mathematical concepts of students who follow the PBL model is higher than the increase in understanding of mathematical concepts of students who follow the conventional model. Thus, the problem-based learning model has an effect on students' understanding of mathematical concepts.
(Hanifah, R dan Arrofa, A, 2017, 2(1), in Java)	Elementary School	> 30 students		Students who use the Problem Based Learning learning model have higher learning outcomes when compared to students who get the lecture method. The use of the Problem Based Learning learning model facilitates student learning by emphasizing problems and problem solving so that students are able to improve learning skills that are more meaningful, think at a higher level and are able to solve problems correctly, which means students have the ability to understand a concept.
(Susanti, dkk, 2019, 3(1), outside Java Islands)	Junior High School	> 30 students		From the results of the calculation it appears that $t_{count}$ is greater than $t_{table}$ then $H_0$ is rejected and $H_1$ is accepted. Based on the final results it can be concluded that the Problem Based Learning (PBL) learning model is better for improving students' understanding of mathematical concept skills than the Take and Give learning model of class VIII students of SMPN 11 Jambi City.
(Eka, dkk, 2019, 7(2), outside Java Islands)	Junior High School	> 30 students		The results of data analysis showed that the median of gain score of student's understanding mathematical concept in PBL model was higher than the median of gain score of student's mathematical concept in conventional learning. Thus, the PBL model affects the student's understanding of mathematical concept.
(Geni, dkk, 2019, 8(3), outside Java Islands)	Junior High School	> 30 students		The results showed that there was an influence of the problem-based learning model of learning with a metacognition approach to students' mathematical problem-solving abilities.
(Andi Yunarni, 2018, 7(1), outside Java Islands)	Junior High School	> 30 students		The Problem Based Learning (PBL) model has an effect on students' mathematical problem solving abilities. This happens because in the application of Problem-Based Learning Model (PBL) students better understand problems, plan problems, solve problems according to plan and examine or interpret solutions.
(Asria hirda, 2017, 2(2), outside Java Islands)	Junior High School	> 30 students		PBL learning model to increase communication skills by 43% and to increase problem solving skills by 58% compared to conventional learning. This means that the communication and problem-solving skills of students who are taught using the PBL learning model are better than the communication and problem-solving skills of students who are taught using conventional learning.

(Ghina, N & Ekasatya, A, A., 2016, 5(1), in Java)	Junior High School	> 30 students	The improvement of mathematical problem solving abilities of students who receive Problem Based Learning and Inquiry learning is high and students' attitudes towards mathematics subjects who receive Problem Based Learning and Inquiry have a good interpretation.
(Gede, dkk, 2017, 5(2), outside Java Islands)	Elementary School	< 30 students	the results of the t-test analysis obtained that tcount is greater than ttable (tcount 15.76 > ttable 2.021) this means that there is a significant difference in mathematical problem solving abilities between groups of students being taught with the Problem Based Learning (PBL) model and the group of students who are taught using the conventional model, it can be concluded that the Problem Based Learning (PBL) model has a positive effect on students' mathematical problem solving abilities.
(Nurma Angkotasan, 3(1), 2014, outside Java Islands)	Senior High School	> 30 students	Mathematics learning with a problem-based learning model is effective in terms of mathematical problem solving abilities in students of SMA Negeri 5 Ternate City. Based on the conclusions above, the suggestion that can be put forward is that mathematics teachers use a student-centered learning model that allows students to be actively involved in mathematics learning activities. Mathematics teachers use problem-based learning models in learning mathematics in addition to linear programming material.
(Ahmad, dkk, 2012, 1(1), in Java)	Junior High School	> 30 students	From the results of the calculation of the average problem solving ability of students in the experimental class is better than the control class. Based on the results of the study, it can be concluded that the Eliciting Activities and Problem Based Learning learning models are effective in problem solving abilities.
(Regina, S, S & Santa, C, M., 2019, 5(1), outside Java Islands)	Junior High School	< 30 students	There is an effect of Problem Based Learning (PBL) learning model on students' mathematical communication skills, so $H_0$ is rejected. The conclusion of this research is learning mathematics on the subject of Pythagoras by using Problem Based Learning model has a significant effect on students' mathematical communication skills compared to those using conventional learning.
(Ayu, dkk, 2017, 5(9), outside Java Islands)	Junior High School	> 30 students	The PBL model has an effect on increasing students' mathematical communication skills. This can be seen from the increase in mathematical communication skills of students who take part in PBL learning is higher than the increase in mathematical communication skills of students who take part in non-PBL learning.
(Eva, M, dkk, 2019, 7(2), in Java)	Junior High School	> 30 students	From the results of research and discussion, it can be concluded that the application of the PBL model has not been effective in terms of ability. student mathematical communication. However, the application of PBL can improve students' mathematical communication skills.

(Lina & Moersetyo, 2014, 3(3), in Java)	Junior High School	> 30 students	The results of this study indicate that: increasing mathematical communication skills of students who receive problem-based learning, problems are better than students who receive conventional learning, most students (81.82%) give a positive attitude towards problem-based learning and a small number of students (18, 18%) gave a negative attitude.
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### Data based on criteria

In the following, a table will be presented based on the inclusion criteria by categorizing them based on four moderating variables, namely the year of research, the level of research, the place of research, and the sample size. Descriptive data are presented in table 2.

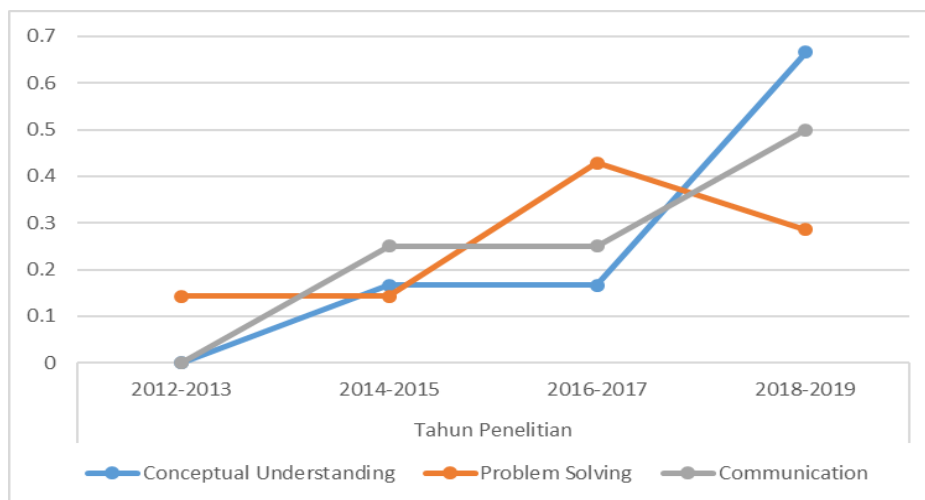
**Table 2. Data based on criteria**

No	Criteria	Mathematical Competence		
		Conceptual Understanding	Problem Solving	Communication
Year of Study	2012-2013	0	1	0
	2014-2015	1	1	1
	2016-2017	1	3	1
	2018-2019	4	2	2
Study Level	Elementary School	1	1	0
	Junior High School	4	5	4
	Senior High School	1	1	0
Research Location	In Java	2	3	1
	Outside Java Islands	4	4	3
Sample Size	≤ 30 people	1	1	0
	> 30 people	5	6	4
<b>Total</b>		<b>6</b>	<b>7</b>	<b>4</b>

Table 2 shows that in the past 8 years, research has been dominated by problem solving improvement and has been published in various indexed journals (Angkotasan, 2014; Juliawan, Mahadewi, dan Rati, 2017; Dzulfikar, Asikin, dan Hendikawati, 2012; Yusri, 2018; Nadhifah dan Afriansyah, 2016; Yanti, 2017; Elita, Habibi, Putra, dan Ulandari, 2019). There is a lot of improvement in understanding the concept of research, but in improving communication, it is still lacking. This is an important thing for researchers to continue to develop mathematical communication skills through PBL. Furthermore, it will be discussed through the moderating variables that have been determined.

### Year of study

There are four groupings based on the time of the study, starting from 2012-2013-2014-2015-2016-2017-2018-2019. The data obtained are as follows.

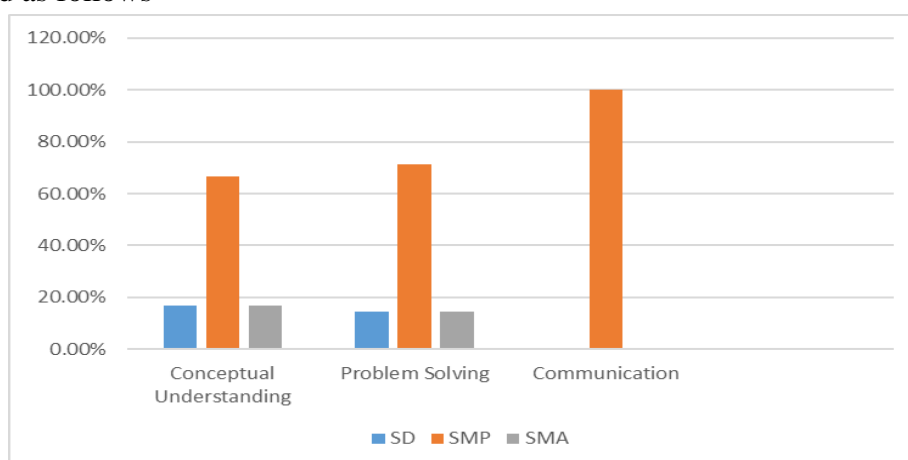


**Picture 1. Data based on year of study**

Picture 1 shows that PBL research to improve mathematics competence tends to increase after 2016-2017 and the ability to understand concepts is one of the most studied concepts of the other two competencies. This shows that the researcher has a good interest in the ability to understand concepts. This shows that PBL has the potential to improve mathematical competence as has been discussed a lot. (Utomo, Wahyuni, dan Hariyadi, 2014; Yulianti & Gunawan, 2019; Yanti, Asnawati, dan Wijaya, 2019; Rahmadani, 2017; Susanti, Basri, dan Relawati, 2019; Asih, Sutiarmo, dan Wijaya, 2019).

### Study level

There are three groupings based on the level of study, namely Elementary School, Junior High School, and Senior High School. The following data were obtained as follows



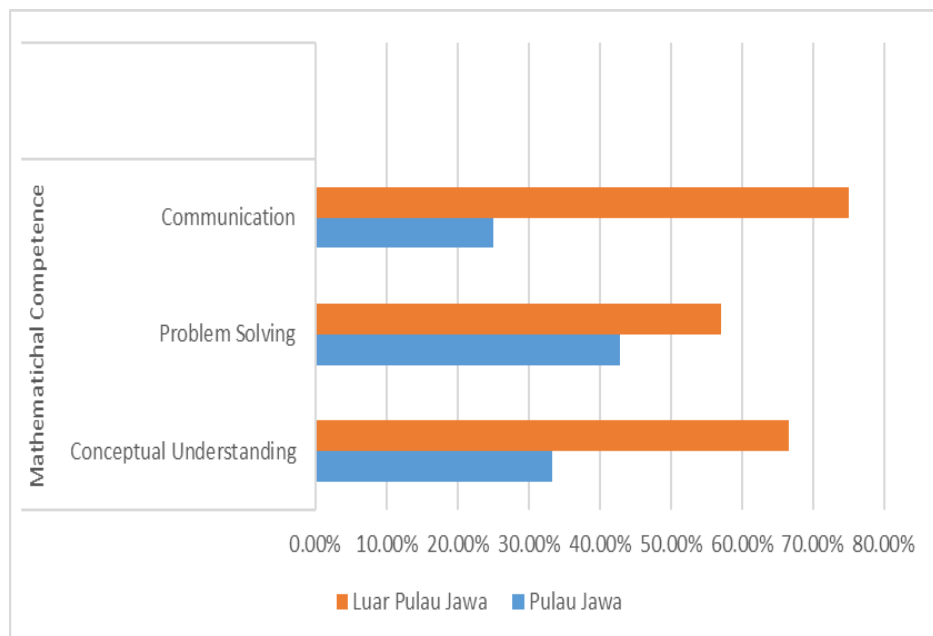
**Picture 2. Data based on study level**



Picture 2 can be concluded that PBL is widely used at the junior high school level. In mathematics, especially communication skills, further research is carried out at the junior high school level (Sinaga & Manik, 2019; Sumunaringtiasih, Koestoro, dan Asnawati, 2017; Mariyati, Noer, Wijaya, 2019; Sari, 2014). Other abilities such as the ability to understand concepts and problem solving skills with PBL are obtained at the elementary and high school levels. However, communication skills were not found at the SD and SMP levels using PBL. This has attracted researchers' attention to conceptual skills and problem solving skills at the primary and secondary school levels.

### Location research

There are two groups based on the research location, namely outside Java and Java. The following data are obtained as follows.

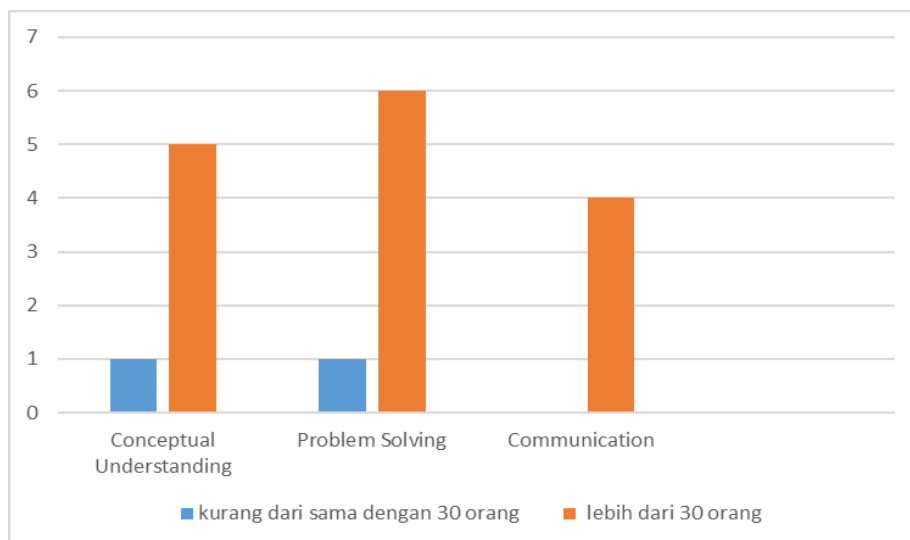


**Picture 3. Data based on research location**

Picture 3 can be interpreted that each period of PBL research on students' mathematical competence is mostly carried out outside Java and the most studied competence is communication skills. However, the mathematical competence that is mostly studied in the area of the island of Java is only problem solving ability. Therefore, this can be considered by researchers in the area of the island of Java. This has also attracted the attention of researchers in the area of the island of Java to be able to conduct research related to PBL on mathematical competence.

### Sample size

There are two groups based on sample size, namely  $\leq 30$  people and  $> 30$  people. The following data are obtained as follows.



**Picture 4. Data based on a sample size**

Picture 4 shows that PBL to improve conceptual understanding and problem-solving skills from the 2012-2019 period was dominated by research with a sample of less than or equal to 30 people, while in communication skills, it was only found for a sample of more than 30 people.

### CONCLUSION

Research that discusses PBL to improve students' mathematical competence for four periods, especially in 2016-2019, has increased. Among problem-solving skills, conceptual and communication skills get a lot of attention to be learned as a teacher's reference in adjusting the selected learning model according to the material to be taught. As for problem-solving, research and publications indexed by Google Scholar, Garuda, SINTA, and Scopus are still minimal.

Research on improving concept, problem-solving, and communication skills through problem-based learning models is mainly carried out at the junior high school level outside Java with a sample of 30 or more. Based on the research results prove that the problem-based learning model has an effect on mathematical competence. The results of the review of 17 articles that became the main study in this study have found variations of student and teacher activities during the teaching and learning process in each primary study research result. From the results of this diversity, it can be concluded that preliminary studies with a wide variety of variations in the large category increase the PBL model on students' communication skills and understanding of mathematical concepts.

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