E-ISSN: 2579-9258
P-ISSN: 2614-3038

Jurnal Cendekia: Jurnal Pendidikan Matematika
Volume 07, Nomor 03, Agustus-November 2023, pp. 2252-2264

The Effect of Problem-Based Learning (PBL) on Improving Students' Mathematical Ability: Meta-Analysis

Qania Agustika Siagian[1]✉, Darhim[2], Dadang Juandi[3], Khairunnisa[4]

[1, 2, 3, 4] Pendidikan Matematika, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudhi No.229 Bandung, 40154, Indonesia
qaniaagustika@upi.edu

Abstract

This study aims to determine the magnitude of the effect and describe studies of the effect of the Problem-Based Learning (PBL) model on increasing students' mathematical abilities. The abilities that can be improved through Problem-Based Learning (PBL) are reflective mathematical abilities, reasoning, critical thinking, spatial, communication, and representation. The method used in this research is the Meta Analysis. Data collection is done by documenting and reviewing various articles relevant to the research topic. The number of articles that match the characteristics according to the target, screening, and inclusion-exclusion criteria found 24 articles (preliminary study). From 2012 to 2021, the results showed that mathematical critical thinking skills dominated research results in increasing mathematical abilities through Problem-Based Learning (PBL). Most of the research was conducted at the junior high school level in Java and Bali with a sample size of 30 or more. The value of the combined effect size of Problem-Based Learning (PBL) implementation has a significant effect on the mathematical ability of students from the primary study analyzed, which is 1.147 in the very high category. The PBL model is highly recommended for use in an effort to improve students' mathematical abilities and instill concepts to students who are still less effective.
Keywords: Mathematical Ability, PBL, Meta-Analysis

Abstrak

Penelitian ini bertujuan untuk mengetahui besaran efek dan mendeskripsikan penelitian-penelitian pengaruh model *Problem-Based Learning* (PBL) terhadap peningkatan kemampuan matematis siswa. Kemampuan yang dapat ditingkatkan melalui *Problem-Based Learning* (PBL) yaitu kemampuan matematis reflektif, penalaran, berpikir kritis, spasial, komunikasi, representasi, dan koneksi. Metode yang digunakan dalam penelitian ini adalah metode meta-analisis. Pengumpulan data dilakukan dengan cara mendokumentasikan dan mengulas berbagai artikel yang memiliki keterkaitan pada topik penelitian. Jumlah artikel yang sesuai dengan karakteristik sesuai target, *screening*, dan kriteria inklusi eksklusi ditemukan 29 artikel (studi primer). Hasil penelitian menunjukkan bahwa pada periode tahun 2012-2021 kemampuan berpikir kritis matematis mendominasi hasil penelitian dalam peningkatan kemampuan matematis melalui *Problem-Based Learning* (PBL). Penelitian banyak dilakukan pada jenjang pendidikan Sekolah Menengah Pertama (SMP) di Pulau Jawa dan Bali dengan ukuran sampel 30 atau lebih. Metode penelitian dari studi primer yang digunakan didominasi oleh kuasi-eksperimen. Berdasarkan hasil penelitian kesimpulan penelitian-penelitian membuktikan nilai ukuran efek gabungan implementasi *Problem-Based Learning* (PBL) berpengaruh secara signifikan terhadap kemampuan matematis siswa dari studi primer yang dianalisis adalah 1.147 dalam kategori sangat tinggi. Model PBL sangat direkomendasikan untuk digunakan dalam upaya meningkatkan kemampuan matemasis siswa dan menanamkan konsep kepada siswa yang masih kurang efektif.
Kata kunci: Kemampuan Matematis, PBL, Meta-Analisis

✉ Corresponding author: Qania Agustika Siagian
Email Address: qaniaagustika@upi.edu (Jl. Dr. Setiabudhi No.229 Bandung, 40154, Indonesia)
Received 18 January 2023, Accepted 23 May 2023, Published 04 August 2023
DoI: https://doi.org/10.31004/cendekia.v7i3.2166

INTRODUCTION

Knowledge has an essential role in human civilization. Knowledge plays a crucial role in improving the quality of superior human resources. Education must be able to prepare skilled human resources in the face of global competition and changes in the world of education. Changes in various lifelines in this era of knowledge, especially the development of information and

communication technology, must be considered necessary in education. The increasing ease of accessibility and convenience and the low cost of knowledge must concern educational institutions. For educational institutions to survive and get high appreciation, they must also change, adapt and improve themselves. One aspect that needs to be changed and improved is the teaching and learning process (Rusman, 2012).

Talking about the learning process, more and more educational institution managers have realized the need for a learner-centered learning approach. The use of learner-centered learning models can be applied to all subjects, one of which is learning mathematics. However, mathematics lessons are still considered difficult by students at school (Kamarullah, 2017, p. 25). It can be seen from some of the results of the evaluation of mathematics which are still low, and the responses of students who still have difficulty working on math problems. This is caused by several factors, one of which is learning mathematics which is still less effective in instilling concepts into students. Solving problems in the mathematics learning process is applying various strategies or gradual learning methods that require students to be active (Isrok'atun & Rosmala, 2019, p. 43).

One method widely adopted to support the learner-centered learning approach and which can empower students is the Problem-Based Learning (PBL) method. Learning with a PBL model begins with a problem that, in this case, can be raised by students or teachers. PBL is a learning approach that uses problems in everyday life as a context for students to learn critical thinking and problem-solving skills and acquire concepts from the subject matter (Anwar & Jurotun, 2019, p. 95). Problems used as the focus of learning can be solved through group work (collaboration) to provide diverse learning experiences for students, such as collaboration and group interaction. Collaborative learning patterns can foster learning experiences and think related to problem-solving. These experiences include making hypotheses, conducting experiments on predetermined hypotheses, conducting investigations from experiments, collecting data from the results of the investigations, making conclusions from the data collected, presenting conclusions accompanied by discussions between friends, and making reports as authentic results from the process. Learning experiences and student thinking (Hamdayana, 2015, p. 140). PBL contains collaborative learning that emphasizes sharing experiences and opinions, not a competition among learners. Collaborative learning is a method of instruction in which students work together in small groups to achieve general learning objectives (Suprihatiningrum, 2017, p. 221).

The PBL model can be used by teachers in the learning process, especially in learning mathematics, because this model is relevant to the objectives of mathematics subjects, especially in improving students' mathematical abilities (Andani et al., 2021, p. 406). This study aims to describe scientifically related PBL models on students' mathematical abilities such as reflective abilities, reasoning, critical thinking, spatial, communication, and representation. The author determines the mathematical ability because he wants to follow up and complete the research (Juandi, 2021). This study determined the mathematical competence of understanding, problem-solving, creative

thinking, and literacy, so the writer was interested in determining the mathematical competence of reflection, reasoning, critical thinking, spatial, communication, and representation.

The method that can be used is a Meta-Analysis. Following the opinion of Gough et al. (Zawacki-Richter et al., 2020, p. 4), a meta-analysis is one the proofs of studies by reviewing existing primary studies and using rigorous and systematic research methods so that they can answer research questions. The sources for this meta-analysis use primary studies or articles published in a journal and, of course, those relevant to the PBL model topic. The characteristics of the selected studies are the year of publication, level of education, sample size, and demographics. By examining the increasing effect of PBL on mathematical abilities, this study can provide a synthesis of evidence that stakeholders such as the government, private sector, researchers, and education practitioners in various universities in Indonesia consider implementing a PBL model as a fundamental practice of national education goals (Sulaiman & Azizah, 2020, p. 114).

The SLR method in this study sets the research questions (RQ) as follows:

QA1: “How is the description of the effect of PBL on mathematical ability based on the year of publication?”

QA2: “How is the description of the effect of PBL on mathematical ability based on education level?”

QA3: “How is the description of the effect of PBL on mathematical ability based on the sample size?”

QA4: “How is the description of the effect of PBL on mathematical ability based on demographics?”

QA5: “How is the diversity of student learning activities and the teacher's role in PBL based on the research results reviewed?”

QA6: “Does the implementation of PBL have a significant effect on students' mathematical abilities from the primary study analyzed? “

MEHOD

This study uses the Meta-Analysis method. The meta-analysis method is carried out by identifying, reviewing, evaluating, and systematically interpreting articles that have a set of standards and, in each process, follow the steps that have been set (Afsari et al., 2021, p. 192; Triandini et al., 2019, p. 63). The design of the meta-analysis research procedure begins with developing research questions and selection criteria, developing the search strategy, the study selection process, and appraising the quality of studies (Cohen et al., 2018, p. 432).

The first step in the meta-analysis method is to determine the research object. This research aims to apply the PBL learning model. The reason for taking this PBL model research object is based on solving the problem of incompatibility of the learning model used with the learning objectives

achieved in mathematics. Choosing a PBL model in learning models is the only solution to these problems.

The next step in using the meta-analysis method is to determine research questions (Research Questions: RQ) based on the reasons for choosing PBL model topics. This study has research questions on the PBL model implementation's effect on improving students' mathematical abilities. The next step is the search process using a search engine (using Google Scholar). It is necessary to search strings to be more specific and avoid filtering too large a number. A search string was performed using the words "Problem-Based Learning Model", ("Mathematics" or "Math"), "Experimental", "Journal", and "Volume". In this step, 113 articles were obtained according to the research object and question. After obtaining these articles, the next step of the meta-analysis method is selecting inclusion and exclusion criteria to decide whether the articles obtained are suitable for this study. The selection criteria are shown in Table 1 below.

Table 1. Inclusion and Exclusion Criteria

No	Inclusion Criteria	Exclusion Criteria
1.	Articles according to research topics about Problem-Based Learning (PBL) models in mathematics lessons	Articles on the topic of research
2.	Research in the form of experiments in applying the PBL model	Research other than in the form of experiments in applying the PBL model
3.	Research place in the territory of Indonesia	Research places outside Indonesia
4.	Publication between 2012 and 2021	Publications before 2012
5.	Full text	Unfull text
6.	Indexed by Google Scholar, Garuda, SINTA, and Scopus	Not indexed

After classifying based on inclusion and exclusion criteria, the next step is the last step of the meta-analysis method is the storage of reports carried out to be analyzed and tabulated in a table based on the mathematical abilities of students classified in the form of research year, education level, sample size, and demographics. The following is the process of research exclusion in screening articles that meet the research targets, which are presented in Figure 1 below.

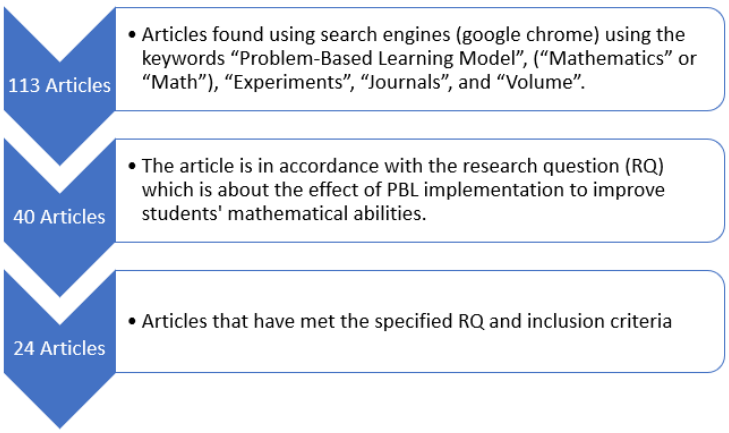


Figure 1. Research Exclusion Process

Thus, from the number of articles found, 113 articles with characteristics according to the research target. Then through the RQ process, 40 articles were taken. After that, the next step was the inclusion and exclusion criteria so that 24 articles were found, tabulated in Table 3 in the research results and discussion section. Primary studies that met the research inclusion criteria found via electronic search engines were from various publisher indexes. The primary studies found were from the Garuda publishing index with 4 primary studies, Google Scholar with 8 primary studies, Scopus Q2 with 1 primary study, Sinta 3 with 5 primary studies, Sinta 4 with 10 primary studies, and Sinta 5 with 1 primary study. It can be shown that most primary studies come from publishers with the Sinta 4 index, while the primary studies from Sinta 2 and Sinta 5 occupy the fewest primary study sources, namely only 1 primary study each.

After obtaining primary studies that meet the research inclusion criteria, then extracting statistical data in the form of sample values, average values, standard deviation values, t-values, and p-values in each experimental class and control class. This statistical data is needed to be able to calculate the effect size of the PBL model on students' mathematical abilities. The formula used to calculate the magnitude of the effect uses the Hedges' formula:

$$\boldsymbol{Hedges's\ g} = \frac{\bar{X}_1 - \bar{X}_2}{S_{within}} \quad (1)$$

Categorization of Hedges' s g value can be classified into several classifications as follows Juandi & Tamur (2020):

Table 2. Category Effect Size

Interval Effect Size (ES)	Category
$-0.15 \leq ES < 0.15$	Neglected effect
$0.15 \leq ES < 0.40$	Low effect
$0.40 \leq ES < 0.75$	Medium effect
$0.75 \leq ES < 1.10$	High effect
$1.10 \leq ES < 1.45$	Very high effect
$ES \geq 1.45$	Very good effect

RESULTS AND DISCUSSION

Based on the suitability of the requirements with the inclusion criteria and exclusion criteria, 24 articles were obtained, which were classified based on several characteristics in terms of reflective mathematical abilities, reasoning, critical thinking, spatial, communication, and representation. The mathematical ability was found in searching for articles from Google Scholar. The survey data obtained are presented in Table 3.

Table 3. Number of Research-Based on Several Study Characteristics

Study Characteristics	Classification	Math Ability					
		Reflect-ive	Reason-ing	Critical thinking	Spatial	Communic-ation	Represent-ation
Research	2012 - 2013	0	0	1	0	0	0

Year	2014 - 2015	0	0	2	0	1	0
	2016 - 2017	1	1	0	0	1	0
	2018 - 2019	0	1	6	0	2	0
	2020 - 2021	1	1	1	1	3	1
Level of education	Primary school	0	1	1	0	0	1
	Junior high school	1	2	5	1	5	0
	Senior High School	1	0	4	0	2	0
Sample Size	< 30	1	1	3	1	2	1
	≥ 30	1	2	7	0	5	0
Demographics (Island)	Sumatera	0	0	4	1	3	0
	Jawa and Bali	1	2	3	0	3	1
	Kalimantan	0	0	0	0	0	0
	Sulawesi and Maluku	1	1	2	0	1	0
	Nusa Tenggara and Papua	0	0	0	0	0	1

Based on Table 3, within nine years, research was dominated by increasing critical thinking skills and followed by improving communication skills. The articles obtained have been published in various journal portals. The journals obtained are indexed by Google Scholar, Garuda, Sinta 6, Sinta 5, Sinta 4, Sinta 3, and Scopus. Obtaining more detailed information will be discussed according to the characteristics set.

Research Year

The classification of the research year is divided into five periods, namely from 2012-2013, 2014-2015, 2016-2017, 2018-2019, and 2020-2021. The data is presented graphically in Figure 2 below.

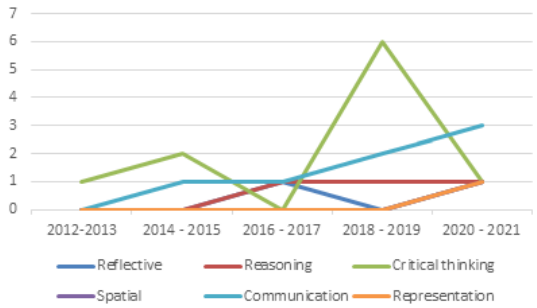


Figure 2. Data by Year of Research

Figure 2 shows that PBL research to improve students' mathematical abilities has increased, especially in 2018-2021. Critical thinking is students' most studied mathematical ability compared to other students' mathematical abilities. This shows an increase in critical thinking patterns in learning with PBL approaches. In addition, there is a relationship between PBL syntax and essential indicators of thinking so that PBL can encourage students' critical abilities (Yunarti & Khairuntika,

2015, p. 333). This follows the results of research observations (Cahyaningsih & Ghufron, 2016, p. 106); learning mathematics with a PBL model provides facilities for students to construct knowledge according to each student's cognitive development stage. Students who have difficulty determining what strategies or methods will be used in solving problems will choose to use their way or according to how the students think. By getting used to students involving each way of thinking, students will be able to think precisely and systematically and follow the rules of logic and scientific reasoning. Critical thinking involves using standards, such as clarity, accuracy, relevance, and completeness. This requires evidence, evaluating, considering alternatives, and fairly and accurately presenting conflicting views (Lau, 2011, p. 1).

Level of Education

Education level classification is divided into elementary, junior high, and high school. Higher education level is not included in this classification because during the search process using a search engine; no research was found that met the inclusion criteria. The data is presented graphically in Figure 3 below.

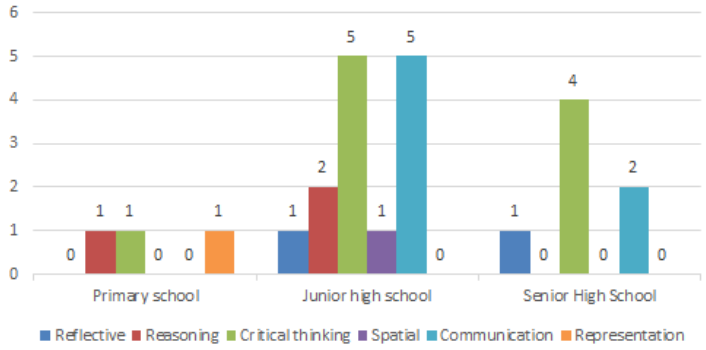


Figure 3. Data by Education Level

From Figure 3, almost all research on the influence of mathematical ability through PBL has been studied at the junior high school level, especially on critical thinking skills. According to (Mortimore, 1999, p. 68), in secondary school learning, there is a quantitative increase in knowledge such as memorization, acquisition for the use of facts and subsequent methods, abstraction of meaning, and interpretive processes at understanding reality. To create a conducive, comfortable, and pleasant atmosphere in the learning process, a teacher must choose a suitable learning model or approach to managing the classroom so that learning objectives will be achieved (Anditiasari et al., 2021, p. 243). With this increase, knowledge about teaching and learning models is needed, one of which can be in the form of PBL learning models. In line with research (Khoiriyah, 2018, p. 63), good classroom management influences the learning motivation of junior high school students. With good classroom management, students will be encouraged to be enthusiastic about learning.

Sample Size

The sample size is classified into two classifications: samples < 30 and ≥ 30. The data is presented graphically in Figure 4 below.

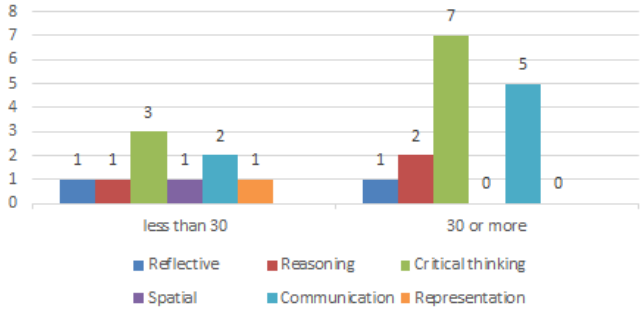


Figure 4. Data Based on Sample Size

From Figure 4, the sample chosen by the researchers to research the effect of PBL in improving mathematical ability is dominated by a sample size of 30 or more. Except for spatial and representational abilities, which are dominated by a sample size of less than 30. Based on the central limit theorem, a sample size of 30 is typically distributed for most studies (Nurudin et al., 2014, p. 1). Thus, the results of most primary studies use a sample size of less than 30. In addition to saving time and money, a smaller sample will be more effective than a sample of more than 30 students. This is in line with the research results (Mahmudah et al., 2018, p. 1) that the application of PBL is more effective when the sample size is set from 1 to 30 students, as seen from the result of the effect size for the sample size of 0.976, which is larger than the sample size of 31 students or more, which is 0.615.

Demographics

Demographic classification is divided into five classifications: the islands of Sumatra, Java, and Bali, Kalimantan, Sulawesi, Maluku and Nusa Tenggara, and Papua. The data is presented graphically in Figure 5 below.

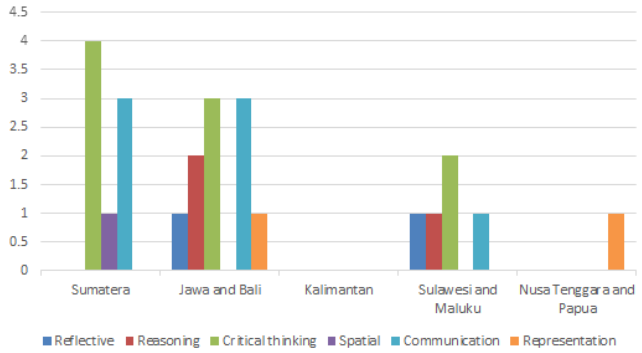


Figure 5. Data Based on Demographics

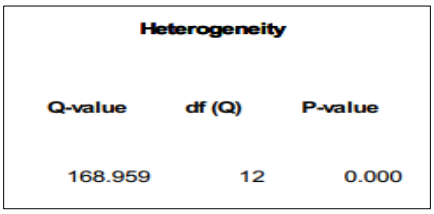
Figure 5 shows that research on the effect of mathematical ability through PBL occurred in Java and Bali, followed by Sumatra Island. On the island of Kalimantan, there was no research on increasing mathematical ability through PBL from 2012-to 2021. Can be shown research results (Bunu, 2014, p. 452) stated that the awareness of the people in the interior of Central Kalimantan towards junior high school, high school, and tertiary education is still not good. The low awareness of the education of remote children in Central Kalimantan is because they have to help their parents work, the distance between school and home is far away, and the children's play environment is not

supportive. This is one of the factors that cause no research on the influence of mathematical ability through PBL to be found in this study.

Based on the review results, the studies' conclusions prove that the PBL model's influence on mathematical abilities is seen in the achievement of the objectives of learning mathematics after the PBL model is applied. This can be seen from the difference in the results of each study's pretest and post-test, which increased after the PBL model's treatment. This is in line with research which has the average score of students on the pretest is 41.03, then the average value increases to 77.60 on the post-test at the end of the lesson (Rahmaeda & Setyawan, 2020, p. 38). Learning with the PBL model aims to facilitate students in the learning and teaching process, significantly facilitating students in understanding the material and exercises given in groups or individually. Learning by implementing PBL can train students to play an active role in teaching-learning, such as actively asking and expressing opinions or knowledge they have learned in class.

Combined Effect Size

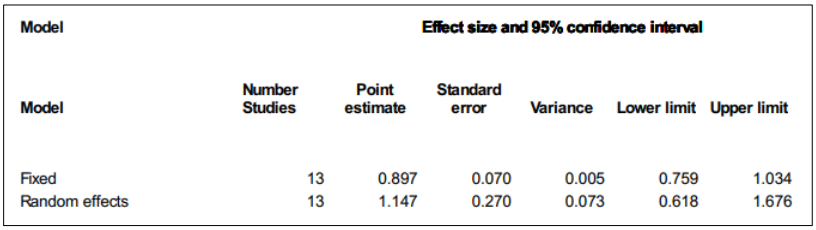
To calculate the effect size value, the help of the Comprehensive Meta Analysis V3 application is needed. The output generated by the application will indicate whether the effect model used is a random effect model or a fixed effect model. The following results from the heterogeneity test of the primary study are presented in Figure 7 below.



Heterogeneity		
Q-value	**df (Q)**	**P-value**
168.959	12	0.000

Figure 7. Heterogeneity Test Results

It can be seen from the p-value, in this case the p-value is 0.000 < 0.05. This means, the estimation model of the combined effect size uses the random effects model. So, to see the size of the combined effect, it can be seen in the row of the random effect model and the point estimation column.



Model		Effect size and 95% confidence interval				
Model	**Number Studies**	**Point estimate**	**Standard error**	**Variance**	**Lower limit**	**Upper limit**
Fixed	13	0.897	0.070	0.005	0.759	1.034
Random effects	13	1.147	0.270	0.073	0.618	1.676

Figure 8. Result of Combined Effect Size Test

The combined effect size in this meta-analysis used is 1,147 which can be categorized into the 'very high effect' category. The effect size values are combined with the Hedges's g formula with the help of the CMA application. It can be stated that the implementation of PBL has a significant

effect on students' mathematical abilities from the analyzed primary studies whose effect size is very high.

Diversity of Student Learning Activities and Teacher's Role

From the results of a review of 24 articles that were used as primary studies in this study, it was found that there were several variations of student learning activities and the role of teachers in each primary study research result. From this diversity, the results of preliminary study research are also varied. As in the preliminary study conducted by (Alghadari, 2016, p. 168), the effect of PBL models on critical mathematical thinking has increased, but the average increase in students' critical thinking skills is still a low category. Let us compare applying the PBL model with conventional learning. It is found that there are primary studies where the results of research between classes using structured PBL learning and conventional classes show no difference, or it can be said that there is no effect on students' communication skills (Sofyan, 2012, p. 26). However, if open PBL learning is applied, it increases in the moderate category. There is a wide variety of student activities and the role of the teacher, which shows the results of various studies.

Various kinds of student activities after the PBL model was applied; namely, students were more focused on working on the given problems, most of the students made mathematical models and explained correctly and did calculations or got the correct solution (Madhavia et al., 2020, pp. 1243–1244). Furthermore, the other diversity of students actively answers and do the exercises given in front of the class or when working in groups. Students also demonstrate a deep conceptual understanding of the material provided and good explanation skills in front of the class (Rahmaeda & Setyawan, 2020, p. 38).

However, all the various student activities resulting from the application of the PBL model cannot be separated from the monitoring and direction of the teacher. At the time of the student orientation process on the problem, where during process, students are expected to be able to issue their ideas to find solutions to the problems given. These ideas arise with the help of teachers who organize students to learn, where teachers help students define the tasks given and guide students in finding solutions to the given problems. So those students can present good work and share tasks with their group friends. Students must communicate with their friends or teachers to increase their communication skills when discussing and presenting their work. Then students can also apply the concepts they get to analyze problem-solving (Manik et al., 2020, p. 106). This also agrees with (Masamah, 2017, p. 13); through scaffolding from the teacher, students will move into the Zone of Proximal Development (ZPD), where new learning will occur through Hypothetical Learning Trajectory.

CONCLUSION

Research on the effect of PBL on increasing mathematical ability for five periods has increased, especially in 2018-2021. Among the reflective, communication, reasoning,

representation, and spatial abilities, critical thinking skills are much attention to be researched to adjust the teacher's task in choosing a learning model to suit the material to be taught. As for the representation capabilities, there is still a lack of research indexed by Google Scholar, Garuda, SINTA, and Scopus.

Research on improving reflection, communication, critical thinking, reasoning, representational, and spatial ability through a PBL model is mainly done at the junior high school level in Java and Bali with a sample size of 30 or more. From the description of the effect of PBL on mathematical ability based on the year of publication, education level, sample size, and demographics. It can be concluded comprehensively that the combined effect size value is 1.147. It can be stated that the implementation of PBL has a significant effect on students' mathematical abilities from the analyzed primary studies whose effect size is very high. From the results of a review of 24 articles that were used as primary studies in this study, it was found that there were several variations of student learning activities and the role of teachers in each primary study research result. From this diversity, it is also concluded that the results of the preliminary study research varied in the major categories of increasing the influence of the PBL model on students' mathematical thinking abilities.

This research can be followed up by other research to find out how much the PBL model improves each mathematical ability such as reflective, communication, critical thinking, reasoning, representation, connection, and spatial abilities. Besides that. to each level of education, research demographics, and sample size.

REFERENCES

Afsari, S., Safitri, I., Harahap, S. K., & Munthe, L. S. (2021). Systematic Literature Review: Efektivitas Pendekatan Pendidikan Matematika Realistik Pada Pembelajaran Matematika. *Indonesian Journal of Intellectual Publication*, *1*(3), 189–197. https://doi.org/10.51577/ijipublication.v1i3.117

Alghadari, F. (2016). Pembelajaran Berbasis Masalah Untuk Meningkatkan Kemampuan Dan Disposisi Berpikir Kritis Matematik Siswa Sma. *Jurnal Penelitian Pendidikan*, *13*(2), 164–171. https://doi.org/10.17509/jpp.v13i2.3428

Andani, M., Pranata, O. H., & Hamdu, G. (2021). Systematic Literature Review : Model Problem Based Learning pada Pembelajaran Matematika Sekolah Dasar. *PEDADIDAKTIKA : JURNAL ILMIAH PENDIDIKAN GURU SEKOLAH DASAR*, *8*(2), 404–417.

Anditiasari, N., Pujiastuti, E., & Susilo, B. E. (2021). Systematic literature review : pengaruh motivasi terhadap kemampuan berpikir kreatif matematis siswa. *Aksioma: Jurnal Matematika Dan Pendidikan Matematika*, *12*(2), 236–248.

Anwar, K., & Jurotun, J. (2019). Peningkatan Aktivitas dan Hasil Belajar Siswa SMA Pada Dimensi Tiga Melalui Model Pembelajaran PBL Berbantuan Alat Peraga. *Kreano, Jurnal Matematika*

Kreatif-Inovatif, *10*(1), 94–104. https://doi.org/10.15294/kreano.v10i1.19366

Bunu, H. Y. (2014). The Awareness on The Children's Education of The Dayak Ethnic. *Cakrawala Pendidikan*, *33*(3), 445–453. https://journal.uny.ac.id/index.php/cp/article/view/2388/pdf

Cahyaningsih, U., & Ghufron, A. (2016). The effects of the implementation of the problem-based learning model on the creativity and critical thinking skills in mathematics learning. *Jurnal Pendidikan Karakter*, *6*(1), 104–115.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods Education* (Eighth). Routledge.

Hamdayana, J. (2015). *Model dan Metode Pembelajaran Kreatif dan Berkarakter* (R. Sikumbang (ed.)). Ghalia Indonesia.

Isrok'atun, & Rosmala, A. (2019). *Model-Model Pembelajaran Matematika* (B. s. Fatmawati (ed.)). Bumi Aksara.

Juandi, D. (2021). Heterogeneity of problem-based learning outcomes for improving mathematical competence: A systematic literature review. *Journal of Physics: Conference Series*, *1722*(1). https://doi.org/10.1088/1742-6596/1722/1/012108

Juandi, D., & Tamur, M. (2020). *Pengantar Analisis Meta*. UPI Press.

Kamarullah, K. (2017). Pendidikan Matematika Di Sekolah Kita. *Al Khawarizmi: Jurnal Pendidikan Dan Pembelajaran Matematika*, *1*(1), 21. https://doi.org/10.22373/jppm.v1i1.1729

Khoiriyah, U. (2018). Pengaruh Manajemen Kelas Terhadap Motivasi Belajar Siswa Di Mtsn 1 Jombang. *Al-Idaroh Jurnal Studi Manajemen Pendidikan Islam*, *2*(2), 49–64.

Lau, J. Y. . (2011). *An introduction to critical thinking and creativity : think more, think better*. John Wiley & Sons.

Madhavia, P., Murni, A., & Saragih, S. (2020). Pengaruh Model Problem Based Learning Terhadap Kemampuan Komunikasi Matematis Siswa Kabupaten Kuantan Singingi. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *4*(2), 1239–1245. https://doi.org/10.32938/jpm.v2i1.569

Mahmudah, R., Ahyan, S., & Rasidi, A. (2018). Pengembangan Media Pembelajaran Matematika Dengan Menggunakan Software Lectora Inspire Pada Materi Perbandingan Untuk Siswa Kelas VII SMP. *Journal Of Honai Math*, *1*(1), 47–55.

Manik, M., Saragih, S., & Zulkarnain. (2020). Kemampuan Komunikasi Matematis Peserta Didik Melalui Pembelajaran Berbasis Masalah (PBM): Studi Quasi Eksperimen di SMA Negeri 1 Pangkalan Kerinci. *JURING (Journal for Research in Mathematics Learning)*, *3*(1), 101–110. http://ejournal.uin-suska.ac.id/index.php/juring/article/view/8957

Masamah, U. (2017). Peningkatan Kemampuan Berpikir Reflektif Matematis Siswa Sma Melalui Pembelajaran Berbasis Masalah Ditinjau Dari Kemampuan Awal Matematika. *Jurnal Penelitian Pendidikan Matematika*, *1*(1), 1–18.

Nurudin, M., Mara, M. N., & Kusnandar, D. (2014). *Ukuran sampel dan distribusi sampling dari beberapa variabel random kontinu*. *03*(1), 1–6.

Rahmaeda, N., & Setyawan, D. (2020). Pengaruh Model Problem Based Learning (PBL) terhadap

Kemampuan Komunikasi Matematika Peserta Didik Kelas X SMA Negeri 3 Maros. *Equals*, *3*(1), 30–40. https://doi.org/10.46918/eq.v3i1.580

Rusman. (2012). *Model-Model Pembelajaran: Mengembangkan Profesionalisme Guru*. Rajawali Pers.

Sofyan, D. (2012). Pembelajaran Berbasis Masalah Untuk Meningkatkan Kemampuan Komunikasi Matematik Siswa Sekolah Menengah Pertama. *Mosharafa: Jurnal Pendidikan Matematika*, *1*(1), 17–28.

Sulaiman, A., & Azizah, S. (2020). Problem-Based Learning Untuk Meningkatkan Kemampuan Berpikir Kritis Di Indonesia: Sebuah Tinjauan Literatur Sistematis. *PEDAGOGIK: Jurnal Pendidikan*, *7*(1), 107–152. https://doi.org/10.33650/pjp.v7i1.792

Suprihatiningrum, J. (2017). *Strategi Pembelajaran: Teori & Aplikasi* (R. K. Ratri (ed.)). Ar-Ruzz Media.

Triandini, E., Jayanatha, S., Indrawan, A., Werla Putra, G., & Iswara, B. (2019). Systematic Literature Review Method for Identifying Platforms and Methods for Information System Development in Indonesia. *Indonesian Journal of Information Systems*, *1*(2), 63.

Yunarti, T., & Khairuntika. (2015). Implementasi Model Problem Based Learning dalam Mengembangkan Kemampuan Berpikir Kritis Siswa. *Seminar Nasional Matematika Dan Pendidikan Matematika, ISBN. 978-602-73403-0-5*, 333–340.

Zawacki-Richter, O., Kerres, M., Bedenlier, S., Bond, M., & Buntins, K. (2020). *Systematic Reviews in Education Research: Methodology, Perspectives and Application*. Springer VS. https://doi.org/10.2307/j.ctt14jxsqg.4