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Problem Based Learning (PBL) with Scaffolding Approach to Improve Students' Mathematical Literacy

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a b s t r a c t

Literacy skills are one of the skills needed by students to solve problems in real life. Therefore, it is necessary to conduct research in developing and improving students' mathematical literacy. The purpose of this research is to analyze the use of PBL with Scaffolding approach to improve students' mathematical literacy. This research method is a literature study, by taking 8 articles that discuss the application of PBL with a Scaffolding approach to improve students' mathematical literacy in Indonesia from 2018-2023. From the research results, the application of PBL with Scaffolding approach to improve students' mathematical literacy can be seen from the aspects of mathematical literacy, namely communication, mathematization, re-presenting, and reasoning and reasoning. Overall, PBL with a Scaffolding approach can improve mathematical literacy by obtaining an Effect Size value of 9.6701 in the large effect category and reinforced by the t-test calculation which found that $|t_{count}| = 10.70037 > t_{table} = 1.965$ then H_0 is rejected, which means that there is a significant difference between the average mathematical literacy of the experimental class and the control class.

K e y w o r d s :
PBL, Scaffolding, Mathematical Literacy

INTRODUCTION

Mathematical literacy skills are integral in learning mathematics (Agustin & Mayasari, 2022). Mathematical literacy helps a person to understand the role of mathematics in life and use it to make the right decisions as a constructive and caring citizen. There are seven components of ability contained in mathematical literacy, namely (1) communication, (2) mathematization, (3) restating, (4) reasoning and reasoning, (5) using problem solving strategies, (6) using symbols, formal language and techniques, (7) using mathematical tools (Nolaputra et al., 2018). According to Wardono & Mariani (2018), students who are able to achieve good mathematical literacy skills can summarize information, present the problem solving process, and find solutions. Meanwhile, students with low abilities have achieved a fairly good level of mathematical literacy skills, at least being able to solve problems in a simple way.

Mathematical literacy has an important role in helping students solve problems related to the application of mathematics in life (Astuti, 2018). In addition, mathematical literacy emphasizes students' ability to analyze, reason and communicate ideas effectively in solving mathematical problems they encounter (Muzaki & Masjudin, 2019). The importance of mathematical literacy has not been matched by the quality of the quality of education in Indonesia, it can be seen from various types of international level assessments that Indonesia participates in, one of which is still ongoing today is the Program for International Student Assessment (PISA) which measures the reading, mathematics and science literacy skills of 15-year-old students or the equivalent of junior high school education. The PISA results show that the mathematical literacy skills of Indonesian students are not optimal. Whereas mathematical literacy there is a correspondence between literacy and subject content standards because in essence the ability to be achieved in the content standards of mathematics learning objectives is mathematical literacy. Seeing the importance of literacy skills in mathematics learning, students are required to have this ability (Madyararti et al., 2019).

According to previous research Istiandaru, Wardono, anda Mulyono (2014) with the title PBL Realistic Saintifik Approach and PISA Assessment to Improve Mathematical Literacy Skills that an average of 37.73 was obtained from the initial test results to determine the mathematical literacy of students in class VIII SMP N 5 Semarang, while the standard set by the school is 60. The problems faced based on student analysis show that students are accustomed to routine problems but are not familiar with non-routine problems or mathematical literacy problems. Teacher analysis shows that teachers find it difficult to implement a variety of innovative learning because they do not have adequate learning tools and assessments have not accommodated students' mathematical literacy skills. This is in line with Sriwahyuni et al (2019) with the title Application of Problem Based Learning Model to Improve Mathematical Literacy Skills of Junior High School Students, related to mathematical literacy problems also occurred at SMP Negeri 2 Sedong, Cirebon Regency. The results of observations and interviews with one of the teachers at SMPN 2 Sedong, found several things related to mathematics learning. During the learning process, not a few students are less enthusiastic about the material presented. This is because students openly express their dislike for math subjects. As a result, many students find difficulty in writing down solutions to math problems or explaining these solutions.

Efforts to improve the quality of learning can be through the selection of appropriate and innovative learning models, one of which is the Problem Based Learning (PBL) learning model. PBL is a learning model by exposing students to authentic and interesting problems so that students can compile their own knowledge, develop problem solving skills and find solutions to the problems given. Students in the PBL model are placed as the center of learning (student centered), namely students are directed to solve problems related to the material to be discussed so that creativity, challenging conditions, contextual and diverse learning experiences will be built. The syntax of the PBL model according to Arends is: (1) provide orientation about the problem to students, (2) organize students to research, (3) assist independent/group solutions, (4) develop and present work, and (5) analyze and evaluate the learning process (Setiawan et al., 2014). Based on research conducted by Akinoglu & Tandogan (Pamungkas & Franita, 2019), it was found that the application of problem-based active learning models had a positive impact on students' academic achievement and their attitude towards learning.

It should also be noted that the key to successful learning that applies PBL also lies in the role of the teacher. The implementation of learning that uses PBL principles needs to be considered by the teacher (Anazifa & Djukri, 2017). In addition, the presence of contexts that are close to students' daily lives is also one of the main keys that can increase students' interest and interest in learning mathematics (Djidu & Retnawati, 2018). Thus, teachers' knowledge in planning and implementing innovative, effective, and fun mathematics learning is the main capital in improving the quality of learning outcomes (Retnawati et al., 2018).

Based on research from Agustin & Mayasari (2022) that the mathematical literacy skills of XI TKR class students of SMKN 3 Bojonegoro with PBL (Problem Based Learning) model are better than the mathematical literacy skills of students with direct learning model. This is in line with research from Pamungkas & Franita (2019) that learning mathematics using problem-based learning can improve students' mathematical literacy skills. This happens because the stages of problem-based learning which include identifying problems, learning independently, investigation, exchanging knowledge, and assessment can facilitate students in improving their mathematical literacy skills.

To help and facilitate students in learning, an approach is needed that can help make it easier for students, namely the scaffolding approach. Scaffolding was first initiated by Vygotsky, a Russian psychologist, which was further popularized by Bruner, a mathematics education expert. Vygotsky came up with the concept of scaffolding, which is to provide a certain amount of assistance to a student during the early stages of learning and then reduce the assistance and provide opportunities for the student to take over increasingly greater responsibilities as soon as he can do it (Lestari et al., 2022). So that this scaffolding will train children to be independent after getting enough help.

Buyung & Dwijanto (2017) say that scaffolding provides a certain amount of assistance to a child during the early stages of learning then the child takes over increasingly greater responsibility as soon as he can perform. This is in line with the opinion of Lestari et al. (2022) that the assistance provided by the teacher is not just assistance but the assistance aims to activate students to think, provide student encouragement but does not mean forcing the will of students, and respect students' opinions even though it is sometimes difficult to accept by teachers and other students.

According to previous research by Buyung & Dwijanto (2017) with the title Analysis of Mathematical Literacy Skills through Inquiry Learning with Scaffolding Strategies that inquiry learning with scaffolding strategies is effective on students' mathematical literacy skills and better mathematical literacy characteristics. This is in line with the research of Fazriah et al. (2021) with the title Improving Mathematical Literacy Skills of Vocational School Students through the Group Investigation Model with Scaffolding Strategies that based on the average pretest and posttest results, there was an increase in the value of students' mathematical literacy skills. The average posttest value tends to increase more after treatment using the Group Investigation model with the Scaffolding Strategy.

PBL learning model has many advantages, but it also has weaknesses that must be anticipated by teachers. Incorporating the scaffolding approach into the PBL syntax is needed to anticipate the weaknesses of this learning method. The scaffolding learning method is one of the methods that can be used by teachers, by providing guidance, encouragement (motivation), attention to students to achieve learning goals. Learning that combines PBL with scaffolding is expected to help students improve their math literacy skills, because in this learning students get help (scaffolding) in each PBL phase according to their needs (Jauhariyyah, 2015).

Thus, the combination of PBL and a scaffolding approach that provides the essence of a learning model that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to gain essential knowledge and concepts from the subject matter is through learning support techniques that in the early stages are given in a more structured manner in improving students' mathematical literacy.

Based on the description above, a literature review was conducted which aims to examine more deeply the ability of mathematical literacy through the application of the Problem Based Learning (PBL) learning model with the Scaffolding approach.

METHODS

The research method used is library research or often called literature research. Literature research is a series of activities related to data collection based on libraries, reading and recording, and processing research materials. Data collection in this study was carried out by searching journals via the internet and library journal collections. From the results of the search for PBL learning models with a Scaffolding approach to improve students' mathematical literacy skills that meet the criteria, namely 8 articles. Quantitative research is also used to process the data that has been obtained to test the research hypothesis.

The research procedure carried out refers to the stages of meta-analysis by Glass (Safaria et al., 2021), namely: 1) determine the research domain to be summarized, 2) select the type of publication collected, 3) collect research results, 4) record research data, 5) calculate the Effect Size of each research result.

The data analysis technique aims to: 1) determine the effect size of mathematical representation ability based on education level, 2) determine the effect size of mathematical representation ability based on year, and 3) determine the effect size of mathematical representation ability based on model/method/approach.

Inclusion Criteria

All study articles in the initial search were examined and assessed for inclusion in the meta-analysis using the following inclusion criteria:

1. Publication year range 2018 to 2023.
2. Articles involving Indonesian authors and published in international, national, or SINTA-indexed journals or proceedings.
3. Study articles reported enough data for Effect Size transformation.

The Cohen's d formula used is as follows:

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s}$$

with

$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

description:

d : Effect Size

$\bar{x}_1$: experimental group mean

$\bar{x}_2$: control group mean

s : pooled standard deviation

n_1: sample size of experimental group

n_2 : sample size of control group

s_1^2 : experimental group variance

s_2^2 : control group variance

Effect Size calculation using cohen's d formula was chosen by researchers because based on the first article found by researchers to find information about Effect Size using cohen's d formula. Then the researcher found the results of research that calculated the Effect Size using the cohen's d formula. In addition, the cohen's d formula was chosen by researchers in using the application in processing Effect Size, cohen's d formula. To calculate the Effect Size, first calculate the combined standard deviation.

The results of the Effect Size calculation are interpreted using the following classification:

Table 1
Effect Size Category

Effect Size	**Interpretation**
$0{,}2 \leq A \leq 0{,}5$	Small
$0{,}5 \leq A \leq 0{,}8$	Medium
$A \geq 0{,}8$	Large

RESULT AND DISCUSSION

Result

Based on the analysis of 8 articles relevant to students' mathematical literacy skills in mathematics learning with PBL model with Scaffolding approach are as follows:

Table 2
Research Results

No.	Code	Article Title (Author, Year)	Research Results
1.	B-1	Penerapan Model Pembelajaran *Problem Based Learning* untuk Meningkatkan Kemampuan Literasi Matematis Siswa SMP (Sriwahyuni et al., 2019)	In the article, the mathematical literacy skills of students whose learning used the PBL model were better than students whose learning was conventional. The subjects of this study were 64 students, 32 experimental class students and 32 control class students. Based on the calculation results, the average value of students in the experimental class was 83.44 and the average value in the control class was 73.13. Also obtained the standard deviation of the experimental class 9.87 and the standard deviation of the control class 7.04.
2.	B-2	*Problem Based Learning On Literacy Mathematics: Experimental Study in Elementary School* (Farhan et al., 2021)	In the article, there were significant differences in mathematical literacy in the experimental and control classes. The mathematical literacy of the experimental class is better than the control class. Student activities in learning mathematical literacy with the PBL model received an A (Very Good) assessment category. Teacher's activity in learning mathematical literacy with PBL model gets assessment category B (Good). The subjects of this study were 43 students, 21 experimental class students and 22 control class students. Based on the calculation results, the average value of students in the experimental class is 78.80 and the average value of students in the control class is 47.50. Also obtained the standard deviation of the experimental class 18.76 and the standard deviation of the control class 14.12.

3.	B-3	*Problem Based Learning Model: It's Effect on Mathematical Literacy Ability Based on Student's Visual Verbal Ability* (Syafitri et al., 2021)	In the article, that PBL learning affects students' mathematical literacy. The subjects of this study were 69 students, 35 experimental class students and 34 control class students. Based on the results of the calculation, the average value of students in the experimental class was 17.2 and the average value of control class students was 10.94. Also obtained the standard deviation of the experimental class 7.05 and the standard deviation of the control class 5.3.
4.	B-4	Pengaruh Model PBL (*Problem Based Learning*) terhadap Kemampuan Literasi Matematika pada Pokok Bahasan Statistik Siswa Kelas XI TKR SMKN 3 Bojonegoro (Agustin & Mayasari, 2022)	In the article, using the PBL (Problem Based Learning) model caused students to have better mathematical literacy skills than using the direct learning model on the subject of Statistics of class XI TKR SMKN 3 Bojonegoro students. The subjects of this study were 60 students, 30 experimental class students and 30 control class students. Based on the calculation results, the average value of students in the experimental class is 75.73 and the average value of students in the control class is 67.2. Also obtained the standard deviation of the experimental class 13.03 and the standard deviation of the control class 14.49.
5.	B-5	Kemampuan Literasi Matematis Siswa pada Pembelajaran Model *Problem Based Learning* (PBL) (Tabun et al., 2020)	In the article, that student's mathematical literacy skills in PBL model learning were better than students in learning without PBL models. The subjects of this study were 60 students, 30 experimental class students and 30 control class students. Based on the calculation results, the average value of students in the experimental class is 86.87 and the average value of students in the control class is 52.73. Also obtained the standard deviation of the experimental class 8.75 and the standard deviation of the control class 11.44.
6.	B-6	Penerapan Model Pembelajaran *Problem Based*	In the article improving the mathematical literacy skills of junior

		Learning untuk Meningkatkan Kemampuan Literasi Matematis Siswa SMP (Muharomah & Setiawan, 2020)	high school students who used the Problem Based Learning learning model was better than improving students' mathematical literacy skills with conventional learning. The subjects of this study were 49 students, 25 experimental class students and 24 control class students. Based on the calculation results, the average value of students in the experiment was 62.00 and the average value of students in the control class was 51.58. Also obtained the standard deviation of the experimental class 15.89 and the standard deviation of the control class 9.53.
7.	B-7	Analisis Kemampuan Literasi Matematis melalui Pembelajaran Inkuiri dengan Strategi *Scaffolding* (Buyung & Dwijanto, 2017)	In the article, inquiry learning with scaffolding strategies is effective on students' mathematical literacy skills and better mathematical literacy characteristics. The subjects of this study were 60 students, 30 experimental class students and 30 control class students. Based on the calculation results, the average value of students in the experiment was 75.55 and the average value of students in the control class was 70.55. Also obtained the standard deviation of the experimental class is 6.17 and the standard deviation of the control class is 1.04.
8.	B-8	Efektivitas *Scaffolding* Metakognitif pada Pembelajaran Matematika di MTs Al Ma'arif Brudu Sumobito Jombang (Rozak & Amrulloh, 2019)	In the article, metacognitive scaffolding learning is effective in improving mathematical literacy which ultimately shows the effectiveness of metacognitive scaffolding learning. The subjects of this study were 53 students, 27 experimental class students and 26 control class students. Based on the calculation results, the average value of students in the experimental learning class is 56.22 and the average value of students in the control class is 47.53. Also obtained the standard deviation of the experimental class 19.36 and the standard deviation of the control class 18.16.

Effect Size is defined as a stage to measure the effectiveness of learning methods or learning models that are tested and applied to students. In addition, with Effect Size, it can be seen the representation of the strength of the influence between the independent variable and the dependent variable, and the value can be compared between studies. The results of the calculation of the Effect Size value show the effect of a treatment given during the study.

The interpretation of the Effect Size value is said to be large if $d \geq 0.8$, said to be moderate if the effect size range is between 0.5 - 0.8, and said to be a small effect if it is smaller than 0.5. Before calculating the Effect Size value, first determine the combined variance. The Effect Size value of each journal can be seen in table 1.

Table 3
Effect Size Value Results

Article Code	Sample		Standard Deviation		Average		Sd Mix	*Effect Size*	Desc
	Exp	Control	Exp	Control	Exp	Control			
B-1	32	32	9,87	7,04	83,44	73,13	1,0887	9,4698	Large
B-2	21	22	18,76	14,12	78,8	47,5	2,5842	12,112	Large
B-3	35	34	7,05	5,3	17,2	10,94	0,7635	8,199	Large
B-4	30	30	13,03	14,49	75,73	67,2	1,8093	4,7145	Large
B-5	30	30	8,75	11,44	86,87	52,73	1,3373	25,53	Large
B-6	25	24	15,89	9,53	62	51,58	1,9206	5,4253	Large
B-7	30	30	6,17	1,04	75,55	70,55	0,581	8,6066	Large
B-8	27	26	19,36	18,16	56,22	47,53	2,6299	3,3043	Large

The calculation of the t-test to determine whether there is a difference between the means of the experimental and control classes is as follows:

a. Determining the Hypothesis

$H_0: \mu_1 = \mu_2$ (there is no significant difference between the mean mathematical literacy of experimental and control classes)

$H_1: \mu_1 \neq \mu_2$ (there is a significant difference between the average mathematical literacy of the experimental and control classes)

b. Determine t_{table} $(\alpha = 0.025)$

$df = n_1 + n_2 - 2 = 456$

$t_{table} = 1{,}965$

c. Determine t_{count}

$$t_{count} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}.(\frac{1}{n_1}+\frac{1}{n_2})}}$$

$$t_{count} = \frac{13{,}43524}{1{,}250231}$$

$$t_{count} = 10{,}70037$$

d. Decision Criteria
   H_0 is accepted when $|t_{count}| < t_{table}$. Conversely, H_0 is rejected when $|t_{count}| \geq t_{table}$. So in this case H_0 is rejected because $|t_{count}| = 10.70037 > t_{table} = 1.965$.
e. Conclusion
   Since H_0 is rejected, it can be concluded that there is a significant difference between the average mathematical literacy of the experimental and control classes

Discussion

Based on the first article entitled Application of Problem Based Learning Model to Improve Mathematical Literacy Skills of Junior High School Students, the Effect Size value is 9.4698 and falls into the large category. This is because students are able to adapt and can follow the learning stages of the PBL model very well.

From the second article entitled Problem Based Learning on Mathematics Literacy: Experimental Study in Elementary School obtained an Effect Size value of 12.112 and entered into the large category. This is because in the PBL learning process the focus of learning activities is entirely on students, namely thinking about finding solutions and understanding the mathematical concepts contained in the problem.

From the third article entitled Improving Problem Based Learning Model: It's Effect on Mathematical Literacy Ability Based on Student's Visual Verbal Ability obtained an Effect Size value of 8.199 and fell into the large category. This is because the PBL model helps students develop abilities in understanding mathematical concepts, mathematical representation, mathematical reasoning, mathematical communication and connections, contextual problem solving, and non-routine questions, all of which are included in the scope of mathematical literacy skills.

From article four entitled The Effect of PBL (Problem Based Learning) Model on Mathematical Literacy on the Subject Matter of Statistics of Class XI TKR SMKN 3 Bojonegoro students obtained an Effect Size value of 4.7145 and fell into the large category. This shows that using the PBL (Problem Based Learning) model causes students to have better mathematical literacy than using the direct learning model.

From the fifth article entitled Students' Mathematical Literacy Ability in Problem Based Learning (PBL) Model Learning obtained an Effect Size value of 25.53 and entered into the large category. This is because students are required to use their knowledge in understanding the problem then expressing the problem in a mathematical model or sketch / drawing and are also encouraged to reason in determining the solution to the problem through group discussions and presentations of discussion results so that their literacy increases.

From the sixth article entitled Application of Problem Based Learning Model to Improve Mathematical Literacy Skills of Junior High School Students obtained an Effect Size value of 5.4253 and fell into the large category. This is due to the new atmosphere when learning. So far, students have learned math with a learning process that only receives material

and practice problems. When the learning process uses the PBL model, students are given the opportunity to play an active role in solving problems, and the teacher only guides. The process certainly shows student involvement in every learning process.

From the seventh article entitled Analysis of Mathematical Literacy Skills through Inquiry Learning with Scaffolding Strategy obtained an Effect Size value of 8.6066 and fell into the large category. This shows that inquiry learning with scaffolding strategies is effective on students' mathematical literacy skills and better mathematical literacy characteristics.

From the eighth article entitled The Effectiveness of Metacognitive Scaffolding on Mathematical Literacy at MTs Al Ma'arif Brudu Sumobito Jombang obtained an Effect Size value of 3.3043 and fell into the large category. This shows that the increase in mathematical literacy shows the effectiveness of metacognitive scaffolding learning.

Of the eight articles found that the Effect Size value is included in the large category. Which means that PBL learning with a Scaffolding approach has a large effect in improving students' mathematical literacy. This is reinforced by the results of the t-test calculation which found that $|t_{count}| = 10.70037 > t_{table} = 1.965$ then H_0 is rejected, which means that there is a significant difference between the average mathematical literacy of the experimental class and the control class. Thus, from the eight articles above, it shows that the increase in mathematical literacy is due to student-centered learning, where students play an active role in solving problems related to everyday life and students are encouraged to reason in determining problem solutions through group discussions with assistance provided by the teacher when students find it difficult to solve problems.

CONCLUSION

Based on the calculation of the Effect Size results, where the average of the Effect Size value is 9.6701 where this value is included in the large category and reinforced by the calculation of the t-test which found that $|t_{count}| = 10.70037 > t_{table} = 1.965$ then H_0 is rejected, which means that there is a significant difference between the average mathematical literacy of the experimental class and the control class. Thus, it can be concluded that PBL learning with the Scaffolding approach has an influence in improving students' mathematical literacy.

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