META ANALYSIS: THE INFLUENCE OF THE PROBLEM BASED LEARNING MODEL ON ENVIRONMENTAL PROBLEM SOLVING ABILITY

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ABSTRACT

Several experimental studies related to Problem-Based Learning on environmental problem-solving abilities have been carried out by previous researchers. This research aims to test how large the effect size is and to determine the impact of the Problem-Based Learning model on the ability to solve environmental problems. The type of research carried out was meta-analysis, namely a narrative review by analyzing the results of previous research publications. The 11 study articles tested revealed that overall the Problem Based Learning model obtained an effect size value of 1,665, which is in the high effect category. Judging from the characteristics of the research, the Problem Based Learning model has an influence in terms of level of study, but does not have an influence in terms of year of research, number of samples and duration of study. The conclusion of this research is that the Problem Based Learning model is able to improve environmental problem solving abilities, as well as having a positive impact on learning that is integrated into environmental problems.

Keywords: Problem Based Learning, Meta-Analysis, Problem Solving Abilities, Environment

INTRODUCTION

Environmental problems are increasing following the economic growth of the community, this shows thatthe existing problems have not been handled (Simatupang and Ionita, 2020). This can occur due to the low problem-solving ability in the community, where the quality of problem solving can be obtained from the educational process (Triani, 2023). Meanwhile, it can be seen that the problem-solving ability of students in Indonesia is still relatively low. Evidenced by the results of the *Programme for International Student Assessment* (PISA) study which in identifying

problems to understand facts and make decisions about nature and changes that occur in the environment, Indonesia is ranked 63 out of 81 participating countries with an average score of 383 in 2022. This average score has decreased compared to 2018 with a score of 396 (OECD, 2023).

One of the learning models that is widely used to support student problem solving is *Problem Based Learning* (PBL). According to Fauzia (2018) *Problem Based Learning* (PBL) is a learning model that involves students in finding solutions to a problem through the scientific method stage, so that students are able to learn knowledge related to the problem and have the skills to solve problems. Experimental studies related to *Problem Based Learning* (PBL) on environmental problem solving skills have been conducted by several researchers in Indonesia and several other countries. So it is necessary to extract as much information as possible from previous research and have a thorough reanalysis in a study to find out how much influence *Problem Based Learning* (PBL) learning has on solving environmental problems using meta-analysis techniques.

The meta-analysis technique is a statistical method to combine quantitative results from several studies to produce an overall summary (K. E. Putri, 2020). There are several meta-analysis studies, such as those conducted by Yustinaningrum (2021) that from 10 articles indexing Google Scholar, an average *effect size* test result of 2.02 was obtained with a very large category, which shows that the *Problem Based Learning* model affects students' mathematical problem solving abilities. Also, Astutik and Jauhariyah's (2021) research from 23 scientific publication articles indexing Sinta 1, Sinta 2, Sinta 3, and Sinta 4 concluded that the absorption of *Problem Based Learning* has a major effect on creative thinking in physics learning with an average *effect size* value of 0.524.

From several meta-analysis studies that exist, most of the articles index on google scholar and there has been no study of *the Problem Based Learning* model for solving environmental problems. Therefore, it is necessary to conduct an in-depth study of the Problem Based Learning model on problem solving capabilities compared to environmental problems.

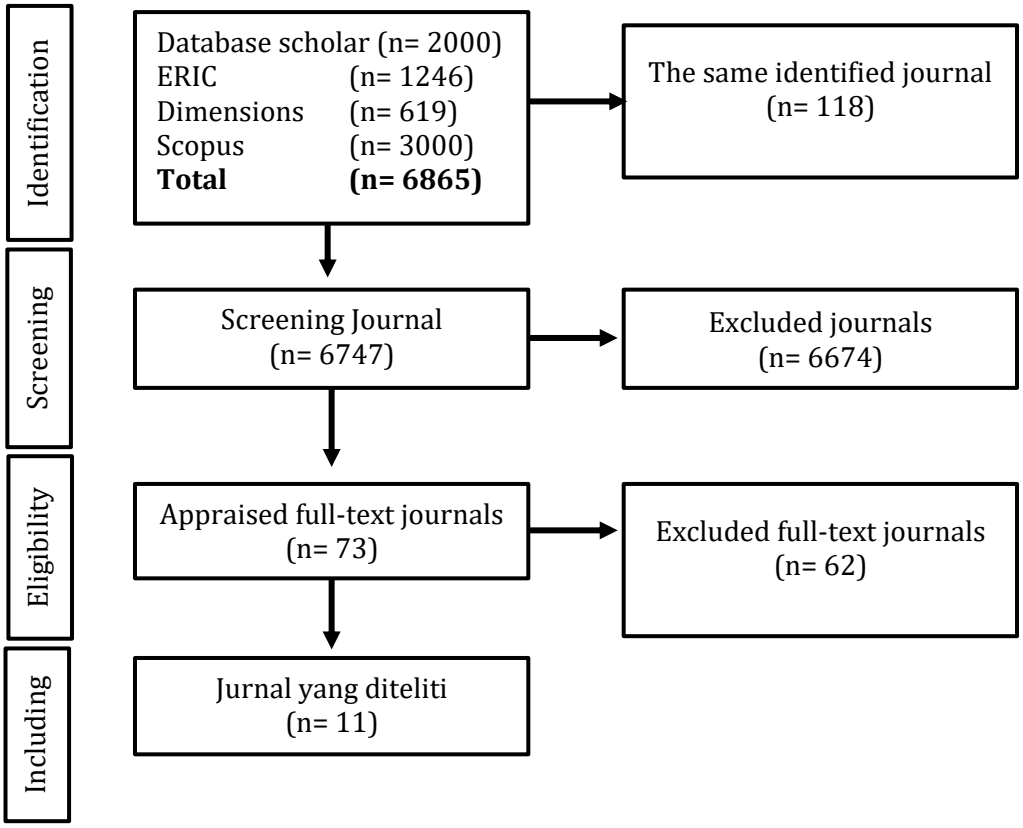
METHOD

The type of research used in this article is a meta-analysis. Meta-analysis is research conducted to summarize, review, and analyze previous research data that has been published nationally and internationally systematically and objectively (Dewi *et al.*, 2020).. Conducting meta-analysis is carried out through 4 steps, namely formulating meta-analysis research problems carried out, collecting and assessing research data from studies or research results as material for analysis, analyzing and calculating effect size, and presenting research data (Utami, 2019).

Research data collection techniques use secondary data derived from previous research. Article data was collected through *the Scholar*, ERIC and *Dimensions* databases and scopus, with criteria using *the group contranst*

experimental research method, which is quantitative research, meeting statistical data on *effcet size* calculations in the form of average values, standard deviations, and sample sizes. In addition, articles published in the range of 2014-2023, have information data on the level of education, and duration of learning.

Picture 1:
PRISMA Flow Diagram



The data collection process is based on PRISMA framework with 4 systematic steps, namely (a) Identification, (b) Screening, (c) Eligibility, (d) Including. The results of the data obtained will then be coded and analyzed statistically descriptively using the help of R-studio software to calculate effect size values, test heterogeneity, and find out publication bias with funnel plot graphs and Fail-safe N analysis from meta-analysis research.

The results of *the effect size* calculation will then be interpreted into categories using Cohen's formula as follows:

Table 1:
Effect Size Category

Quantity d	Category
d ≥ 0,8	Large
0,5 ≤ d < 0,8	Medium
d < 0,5	Small

FINDINGS AND DISCUSSION

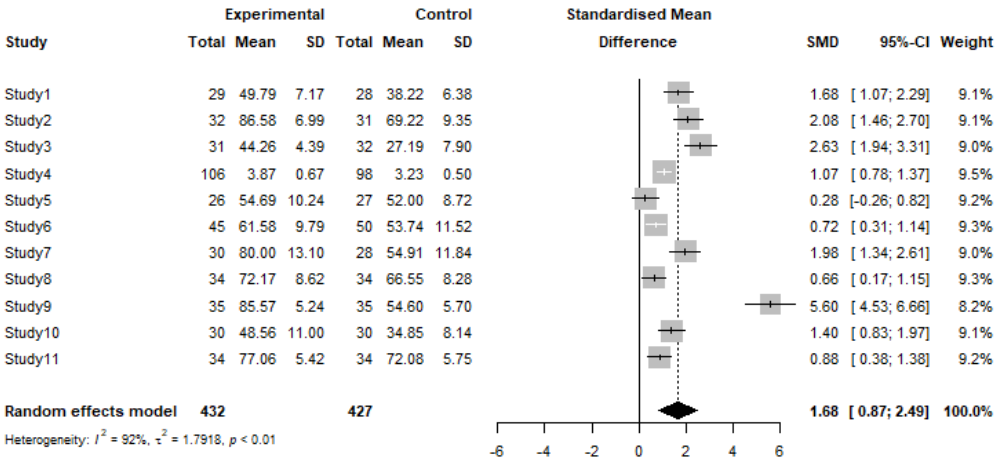
This research aims to determine the effect of the Problem Based Learning (PBL) model on environmental problem solving abilities using meta-analysis. To find out the influence obtained in Problem Based Learning (PBL), a large calculation (effect size) is needed to be able to analyze the influence contained in Problem Based Learning (PBL). Of the 73 study articles according to the topics obtained from the analysis stage, only 11 study articles matched the research characteristics. A total of 11 appropriate study articles will then be summarized in coding form and the effect size data can be analyzed using R-studio software.

1. Overall Effect Size Results Data

From the results of the analysis of 11 articles, *a forest plot* was generated that contained a graphical representation of the meta-analysis findings by displaying the effect size and confidence interval for each study article. Picture 2 shows the distribution of effects on each study article included in the meta-analysis. The effect distribution or effect size value of each study is represented in the SMD (Standardized Mean Difference) value. The overall *average effect size* shows 1.68 (large category). This number means that treatment with *the Problem Based Learning* (PBL) model can improve the ability to solve environmental problems. Thus, the *Problem Based Learning* (PBL) model is able to show the influence on students in the teaching and learning process that is aligned with environmental problems or known as *environmental learning (Environment Learning)*.

Picture 2:

Forrest Plot data as a whole

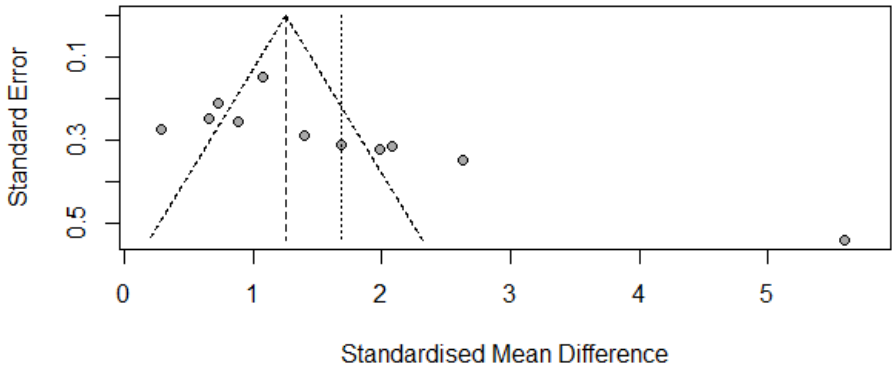


In line with the results of research conducted by Firmansyah et al. (2022) with the findings of the *Problem Based Learning* intervention meta-analysis study on solving physics problems, an average *effect size* of 2.067 was obtained categorized as a large effect.

In addition, a publication bias test was conducted to see if there were studies that systematically differed from all study results to be analyzed. Publication bias tests were conducted using results from *funnel plots* and *fail-safe N* (FSN).

From Picture 3 it appears that the *effect size* values are spread almost symmetrically in the middle of the *funnel plot,* and on the left and right sides of the vertical lines. The vertical line shows the combined *effect size*. It can be noted that the distribution of *effect size* distribution is not completely symmetrical, so it is necessary that Rosenthal's *fail-safe N* (FSN) value be identified to determine whether there is a possibility of publication bias or not (Tamur *et al*., 2020).

Picture 3:
Diagram Funnel Plot



Picture 4:
Calculate the fail-safe N (NFS) value or R-studio software

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Fail-safe N Calculation Using the Rosenthal Approach

Observed Significance Level: <.0001
Target Significance Level:   0.05

Fail-safe N: 1252
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The result of *the fail-safe value N* (FSN) is obtained with the help of R-studio software with a value of 1252. In Rosenthal's approach, studies said to avoid publication bias can be calculated by the equation if the safe file N > 5K + 10 (K = Number of studies) → 1252 > 5(11) + 10 = 1252 > 65, because the result is 1252 greater than 65 hence indicating that the studies involved in the meta-analysis are not susceptible to publication bias or spared from publication bias.

Table 2:
Heterogeneity of the Effect of Distribution Size

Heterogenity			
Q	**d.f**	**Het. P-Value**	**I^2**
121,70	10	< 0.0001	91,8%

In the heterogeneity test the Q value was 121.70 with 10 degrees of freedom (d.f), and the heterogeneous p-value was less than 0.0001, indicating that there was a statistically significant heterpgenicity among the results of the studies in the meta-analysis. So it can be concluded that the variations of the 11 studies analyzed are diverse, so the potential for variable moderator analysis is carried out. Then the value of I^2 = 91.8% indicates that the diversity of the variation of the 11 studies analyzed is very high, this indicates a significant heterogeneity among the results of the studies analyzed. In other words, about 91.8% of the total variation in the combined study results was due to heterogeneity, while the remaining 8.2% was likely due to measurement errors or other factors.

Table 3:
Random Effect Model

Estimate	**95%-CI**		**z**	**p-Value**
	Lower bound	**Upper bound**		
1,6810	0,8692	2,4928	4,06	<0,0001

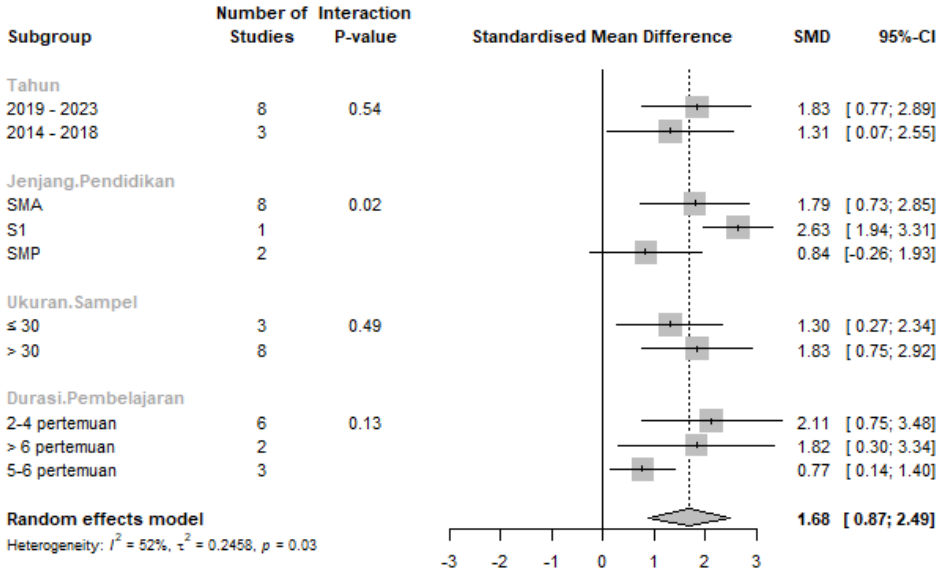
The estimate value shows the combined effects of the 11 studies we analyzed in the *Random-Effects* model of 1.6810. This shows that there is a significant difference between the experimental and control groups in the meta-analysis. Then from the 95% confidence interval shows the range where the actual effect value is at the lower limit of 0.8692 and the upper limit of the value of 2.4928. The z value in the number 4.06 indicates that the observed effect size has a statistically significant difference from zero. And the p-Value value <0.001 shows a statistically significant effect. It can be concluded that the impact of learning using the *Problem Based Learning* (PBL) model is quite effective and has a positive impact in improving the ability to solve environmental problems.

2. Analysis Reviewed from Research Characteristics

When viewed from the characteristics of the study, where the 11 studies analyzed were grouped based on research characteristics, covering study years, namely 2014-2018 and 2019-2023; education levels, namely junior high, high school and college; sample size, namely 30 and > 30

students; and the duration of learning, namely 2-4 meetings, 5-6 meetings, and > 6 meetings. The results of the analysis of large effects in terms of research characteristics can be represented by forest plot data in picture 5.

Picture 5:
Forest Plot Graph in View of Research Characteristics=



a. Based on Year of Research

The first is reviewed from the study year which is classified into two groups with a range of 2014-2018 and 2019-2023. Grouping on the characteristics of this year exists to determine the renewal every 5 years in the studies obtained. It can be seen that the *effect size* in Picture 5 for the study group (2014-2018) is 1.31 and for the study group (2019-2023) is 1.83. Both study groups were in the high-effect category. Then, when viewed from the results of *the effect size* of the two, it can be concluded that the application of *Problem Based Learning* (PBL) is more significant for problem solving ability in 2019-2023.

While the p-value shows 0.54 > 0.05 which shows no significant difference between groups. With regard to this finding, which means that in the context of the meta-analysis in this study it can be said that there is no statistically significant effect applying *Problem Based Learning* (PBL) with *effect size* between study groups in terms of the year of research. In line with research conducted by Musna (2020) that the application of *problem-based learning* to students' mathematical problem-solving ability has no difference in effect between study groups in terms of study year.

b. Based on Education Level

Judging from the level of education in Picture 5, it is known that the largest *effect size* is obtained at the undergraduate education level (S1) with an effect value of 2.63 (high effect category), high school level of 1.79 (high effect category) and junior high school level with an effect value of 0.84 (high effect category). While the p-value shows numbers 0.02 < 0.05 which shows that the difference between groups is quite statistically significant. With regard to this finding, which means that in the context of the meta-analysis, it can be said that statistically there is an influence on the application of *Problem Based Learning* (PBL) with *effect size* between study groups in terms of education level.

The results of the application of *Problem Based Learning* (PBL) to the ability to solve environmental problems are most effectively used at the Bachelor (S1) education level. In line with the results of Astutik and Jauhariyah's (2021) research which states that based on *the effect size value,* the university level has the largest *effect size* value of the high school, junior high and elementary school levels in the implementation of PBL. These findings can be caused by several factors, such as differences in the development of children's cognitive maturity levels. According to Piaget, the cognitive development of S1 students is at the stage of formal operations, the stage of formal operations is after the age of 11 years and over where they are able to think abstractly and logically (D. F. S. Putri, 2022).

In addition, there are other factors that affect the size of the *effect size* at the S1 level such as analytical and critical abilities. As explained in the Wulandari pelitian (2018) that at the student level can actively be able to make solutions to problems given in the Problem Based Learning model. In addition, previous educational experience can also have a major effect on the S1 / college level. In line with Astutik and Jauhariyah's research (2021) which explains that at the university level, students may have more experience which results in the process of assimilation, accommodation and equilibrium can continue to occur compared to students at other levels.

c. Judging from Sample Size

In this study, researchers grouped or interval the sample size into 2 categories, namely ≤ 30 students and >30 students. This categorization was made because it is known that the minimum sample size range of the 11 article studies observed was 26 students to 106 students. The *effect size* data reviewed from the sample size in Picture 5 shows the magnitude of the effect obtained for the sample size of ≤ 30 students is 1.30, while the sample size of > 30 students is 1.83. Both sample size study groups were both high effect categories. However, if you look at the *value of the effect size* of both, it can be concluded that the application of *Problem Based Learning* (PBL) to problem solving ability has more influence on the sample size >30 students.

As for the p-value shows numbers 0.49 > 0.05 which shows no significant differences between groups. In other words, the application of *the Problem Based Learning* (PBL) model in terms of sample size does not affect the ability to solve environmental problems. This is in line with the conclusion of a meta-analysis study conducted by Demirel and Dagyar (2016) that *effect size* in the research group is not one of the characteristics that affect students' abilities. In addition, it is also supported by research conducted by Musna (2020) that there is no influence between *effect size* and sample size. This condition can be caused because sample selection (sampling) has been carried out appropriately and according to procedures for large and small sample sizes so that the selected sample is truly a representation of the population used by the researcher.

d. Judging from the Learning Duration

In the selected research characteristics, the minimum learning duration was carried out 2 meetings to 15 meetings, because there was one study whose learning duration took three months. So that from the difference in time span, the categorization of the study group was made into three groups, namely the duration of 2-4 meetings, the duration of 5-6 meetings and the duration of > 6 meetings. Data on *the effect size of the Problem Based Learning* (PBL) model on the duration of learning seen from Picture 5 obtained that *the effect size* for the duration of 2-4 meetings was 2.11 (large effect category), while for the duration of > 6 meetings was 1.82 (large effect category), and the duration of 5-6 meetings was 0.77 (medium effect category). The magnitude of *the effect size* value on the learning duration with 2-4 meetings is higher than the learning duration of >6 meetings and 5-6 meetings. This can happen because adequate learning duration and a detailed explanation of the use of *Problem Based Learning* can extend the storage period in student working memory. Similarly, Yew and Goh (2016) explained that problem orientation in the PBL stage also requires adequate time to investigate individuals and groups to achieve the desired learning outcomes.

The p-value of this characteristic found a number of 0.13 greater than 0.05 which showed no significant difference between groups. In other words, the application of *the Problem Based Learning* (PBL) model in terms of sample size does not affect the ability to solve environmental problems. This is in line with the results of research obtained by Demirel and Dagyar (2016) which showed the results that the application of PBL did not have a different effect between study groups in terms of learning duration.

CONCLUSION

Overall, the *Problem Based Learning* (PBL) model is able to improve the ability to solve environmental problems with *an effect size* value of 1,665 which is in the high effect category. So that the *Problem Based Learning* (PBL) model has a positive impact on learning that is integrated into

environmental problems on problem-solving abilities. For future researchers, it may be possible to analyze more study characteristics and be able to review PBL differences with other models such as PjBL.

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