Meta Analysis: Influence of Problem Based Learning Model on Critical Thinking Skills in Mathematics of Junior High School Students

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ABSTRACT

Critical thinking skills have an impact on mental activities such as problem solving, decision making, hypothesis analysis, and scientific research. One way to improve critical thinking skills is through the application of learning models, such as Problem Based Learning (PBL) model. This study aims to determine the effect of Problem Based Learning model on junior high school students' mathematics critical thinking skills as a whole and in terms of grade level. Based on the meta-analysis conducted on 38 scientific publication articles show that Problem Based Learning model has a significant positive effect in improving the overall critical thinking skills of junior high school students in mathematics. The analysis also showed that the effect of Problem Based Learning model varied depending on the grade level, with grade IX having the most significant effect. Therefore, it can be concluded that Problem Based Learning has a positive impact on junior high school students' mathematics critical thinking skills.

Keywords: Meta-analysis, Problem Based Learning, Critical Thinking Mathematics in Junior High School

1) INTRODUCTION

Education is any form of effort that is carried out consciously in the form of coaching the mind and body throughout the life of the individual with the aim of improving their personality in order to take a role in various environments in the future (Purwanto, 2014: 24). Education is important for everyone because with education a person will get useful knowledge in order to develop his abilities and personality. Education is a process that takes place continuously, especially in a school environment. One of the lessons that is very important and taught at all levels of education is mathematics.

According to (Triswidrananta et al., 2020: 4) mathematics is a general science that underlies the development of modern technology and has a very important role in various disciplines and advances human thinking in improving the achievement of knowledge and the achievement of skills. The National Educational Tegnology Standarts for Student (NETS-S) states that students must have 6 important skills and be taught by teachers at school, one of which is critical thinking skills.

Critical thinking skills are one of the characteristics that influence mental activity in problem solving, decision making, hypothesis analysis (analysing assumptions) and scientific inquiry (Astika et al., 2013). According to Scriven and Paul that critical thinking involves the ability to apply, analyse, evaluate, and explain the results of information obtained from observation, experience, thought, reasoning, or communication. However, in reality, students' mathematics critical thinking skills are still relatively low. The low level of students' critical thinking skills based on research conducted by Prihono & Khasanah (2020: 5) is due to the fact that only a few students show activeness in presenting and developing their potential in arguing and asking questions. This is also evidenced by the results obtained from the International Programme for Student Assessment (PISA) in 2018 which showed that the mathematics skills of Indonesian students in the average score reached 379 from the OECD average score of 487 and ranked 72 out of 78 countries (Kemendikbud, 2019). Because critical thinking is a skill that can be developed through students' direct experience in dealing with problems, so that learning environments involving real problems must be provided by teachers in the process of learning mathematics (Nafiah & Suyanto, 2020: 43). One learning model that provides a learning environment that supports students' critical thinking skills in mathematics is Problem Based Learning (PBL).

According to (Ashari, 2020) Problem Based Learning often referred to as Pembelajaran Berbasis Masalah is a learning process that links students to a reality problem that spurs them to research, describe, and find solutions so that students not only learn knowledge, but are able to experience and feel. In addition, students use critical thinking stages in the PBL learning process, namely investigating problems, analyzing based on evidence, and making decisions based on the results of the investigation. Because there have been many studies found on the effect of the Problem Based Learning model on students' critical thinking skills, so a study is needed that can bring together various previous research results to obtain broader information called meta-analysis research (Retnawati et al. 2018: 5).

Meta-analysis is a form of study that uses data from existing studies and analyses them in a systematic and quantitative way to obtain broad conclusions (Retnawati et al. 2018: 2). The purpose

of this study is to summarize and get the essence of research results from a number of previous studies. In this study, researchers will collect several research reports that have the same topic to be analyzed (Sari, Tyas, and Hardini 2020).

Based on the search results from various references, there are still few meta-analysis studies from the Junior High School (SMP) level related to the problem-based learning (PBL) learning model on students' mathematics critical thinking skills. Based on these problems, researchers are interested in conducting research with the title "Meta-analysis: The Effect of Problem Based Learning (PBL) Learning Model on Mathematics Critical Thinking Ability of Junior High School Students".

2) METHODS

The method applied in this study is a quantitative method that uses a meta-analysis research design with the Group Contrasts meta-analysis research type because it involves two or more groups of respondents to be measured and compared, then reports the results of the analysis in the form of descriptive statistics. In this study, the form used is experimental research. According to Lipsey & Wilson in (Retnawati et al. 2018) experimental research is a type of research that compares groups of respondents based on the experimental conditions they receive (treatment group and control group). The difference or contrast between the experimental group and the control group on the measured variable is interpreted as the effect size.

The population in this study is scientific publication articles in the form of theses, national and international journals with the keywords "Problem Based Learning" and "critical thinking skills of junior high school mathematics students" published in the last 10 years, namely 2012-2022. The researcher collected data by searching for publication articles relevant to the topic to be researched on internet network sites such as Google Scholar, Academia, Onesearch, Crossref, Semantic Scholar, Repository, Scopus, and Publisher Page. The sampling technique used the flowchart technique from PRISMA. The instrument used was a data coding sheet. The data were analyzed by calculating the effect size value using the standardized means difference formula. Then calculate the summary effect value as the conclusion of the research results.

3) RESULTS AND DISCUSSION

Based on the results of data collection, 84 scientific publication articles were obtained related to the effect of the Problem Based Learning (PBL) learning model on the critical thinking skills of junior high school mathematics students. The articles collected consisted of 12 undergraduate theses, 4 postgraduate theses, 62 national journals, and 6 international journals published on various online search sites within the last 10 years (2012-2022). However, there were only 38 scientific publication articles that met the criteria to be sampled in this study which were then further analyzed by meta-analysis to obtain the effect size value and summary effect as the final conclusion.

1. Value Summary Effect of Problem Based Learning Model Effect on Mathematics Critical Thinking Ability of Junior High School Students

The data from the calculation of effect size in the meta-analysis research are as follows:

Table 1. Overall Effect Size Grouping Data

Category Effect Size	**value *Effect Size***	**Number of Articles**	**Percentage**
Small	0 <	4	10,5 %
Medium	0.20 <	16	42,1 %
Large	0.50 <	5	13,2 %
Very Large		13	34,2%
TOTAL		**38**	**100 %**

Based on the table, it is obtained that of the 38 scientific publication articles, there is a percentage effect size of 34.2% with a very large category consisting of 13 articles. Then articles that have a large

category effect size amount to 5 articles with a percentage of 13.2%, 16 articles with a percentage of 42.1% have a medium category effect size, while the effect size for the small category has a percentage of 10.5% with a total of 4 articles. Furthermore, to show the overall average of the 38 scientific publication articles, a heterogeneity test was conducted using JASP 0.16.3 software to determine which statistical model is more appropriate to use in calculating the summary effect value or average effect size. Because the calculation results show that the p-value <0.05 and the Q>df value, it can be concluded that the effect size of each study analyzed is heterogeneous, so the more accurate statistical model used is the Random Effect Model.

Table 2. Summary Effect with Overall Random Effect Model

Coefficients						
					95% Confidence Interval	
	Estimate	**Standard Error**	**z**	**p**	**Lower**	**Upper**
intercept	0.805	0.140	5.772	< .001	0.532	1.079

Note. Wald test.

The results of the analysis using the random effect model show that the weighted summary effect value (***M***) or the average effect size of the publication articles used as the overall research sample of 0.805 is in the very large category. If the summary effect is very large, it is said that the average difference between the groups is very large, meaning that the overall average score of students' critical thinking skills in the experimental class is higher than the control class (Gazali 2017: 102). This is in line with research conducted by (Meilinda et al. 2019: 88) with the results of the average value of the experimental class (75.46) higher than the average value of the control class (51.89). In Habib Husnial

Pardi's research, he also said that applying the problem-based learning (PBL) learning model can have an effect on students' critical abilities because it familiarizes students to be more actively involved, willing to try to solve their own problems by discussing with their group friends, eager to find solutions, and able to make their self-confidence begin to emerge so that they are accustomed to and continue to want to try to solve the given math problems themselves (Pardi, 2021: 96).

Based on the results, the value of $Z = 5.772$ with a p-value <0.001 so it can be concluded that the Problem Based Learning learning model as a whole has a significant positive effect on the critical thinking ability of junior high school students in mathematics.

2. Value Summary Effect in terms of Class Levels

From the effect size data, the analysis results obtained from 38 learning research articles with problem based learning models on students' critical thinking skills in mathematics, then interpreted based on the grade level at the junior high school level, namely grades VII, VIII, and IX. The summary effect results obtained based on class level are as follows:

Table 3. Summary of Article Effects in terms of Class Levels

Class Level	**Number of Articles**	***Summary Effect***	**Category**
VII	6	0,380	Medium
VIII	25	0,662	Large
IX	7	1,793	Very Large

The results obtained from the use of the problem-based learning (PBL) learning model in improving the critical thinking skills of mathematics junior high school students in grade VII obtained a summary effect value of 0.380 with a moderate category of 6 scientific publication articles analyzed. The summary effect value for grade VIII with a total of 25 articles is in the large category, namely

0.666. Meanwhile, at the IX grade level, it produces a very large category with a summary effect value of 1.793 as many as 7 articles.

The VII grade amounted to 6 articles with a summary effect value of 0.380. This value shows that the average effect size of all scientific publication articles in class VII which is used as a research sample has an effect (significant) with the summary effect category classified as moderate. This means that the problem-based learning model is effectively used for teaching and learning activities in improving students' critical thinking skills in mathematics in the medium category. So this means that the average difference between one group and another is not large, nor small. The large value depends on the researcher's judgment by considering all the circumstances (Gazali 2017: 102). Similarly, the results of Ratnawati et al.'s research (2020: 49) explain that the application of the PBL learning model is more significant than the conventional learning model, where the average effect size test results = 0.656 or 66% is classified as moderate. During the PBL learning process, students try to identify a problem contained in the discussion material, helping students build their own knowledge to be more independent and responsible, able to find solutions to the problems given, and students can be more critical and active in responding to the results of presentations from other groups by submitting opinions openly, although there are some students who choose to be silent or do not want to give opinions.

At the VIII grade level, the number of scientific publication articles analyzed was 25 scientific publication articles and included a large category with a summary effect value of 0.662, indicating that the 25 articles analyzed had an effect (significant). The application of the PBL model in class VIII can be stated as more effective in improving students' critical thinking skills in mathematics than in class VII, because the summary effect value obtained is greater. These results are in line with the research of Steven et al., (2019: 25) which states that there is an effect of the problem-based learning (PBL) learning model on the mathematical critical thinking skills of grade VIII junior high school students seen from the level of student activeness in participating in learning categorized as good. There are several things that cause the experimental class score to be better (59.55) than the control class (51.52), including learning with the PBL model is not teacher-centered, so students are more required to be active. In addition, students work on problems seriously and based on what they understand.

Meanwhile, for class IX, the summary effect value of 1.793 was obtained, including a very large category with a total of 7 articles. So the results show that of the 7 articles related to the problem-based learning (PBL) learning model obtained a very large effect when applied in improving the critical thinking ability of mathematics junior high school students in grade IX. Compared to classes VII and VIII, class IX which obtained a greater summary effect value can be stated that the application of the PBL model is more effective in improving students' critical thinking skills in mathematics, because the summary effect value produced is classified as a very large category. In class IX students are considered more mature in regulating and organizing their way of learning so that it is easier to follow the stages in the learning model, so as to create a conducive learning atmosphere as expected based on the objectives to be obtained. The results of this study are in accordance with the theory of the researcher who revealed that a child's social thinking is influenced by his cognitive maturity (Syah, 2015: 36).

Based on the results of the analysis of the three junior high school grade levels, it can be seen that the highest average effect size or summary effect is in grade IX. Thus it can be concluded that in terms of grade level, the Problem Based Learning (PBL) learning model has an effect (significant) in improving the critical thinking skills of junior high school students and the class that is more effective in applying the problem-based learning model in improving students' critical thinking skills in mathematics is grade IX.

3. Influence of Problem Based Learning (PBL) Model on Mathematics Critical Thinking Skills for Junior High School Students

Based on the results of the analysis using the random effect model, the summary effect size is 0.805. This value shows that the average effect size of all studies used as research samples is included in the category of very large effect size.

The problem-based learning (PBL) model is one of the lessons that emphasizes students gaining experience in solving problems, improving communication skills, thinking, cooperation, and the ability to elaborate on existing sources to be used as a reference in formulating ideas in overcoming problems (Sukmawati 2020: 66). Based on the findings and analysis conducted in the study, learning by applying the PBL model can improve critical thinking skills, especially in mathematics learning. The increase in critical thinking skills occurs because the learning atmosphere that occurs when applying the PBL

model supports student activities to think critically in solving mathematical problems that have been presented by the teacher.

To draw conclusions from the research results, it can be seen with the Z test. Because the value of $Z = 5.772$ with p-value <0.001 and 95% confidence interval ranging from 0.532 to 1.079, it can be ascertained that the confidence interval does not contain 0 (zero) in this case H_0 is rejected. Thus it can be concluded that the problem-based learning model affects the critical thinking skills of junior high school students in mathematics.

4) CONCLUSION

Based on the findings and discussion in this study, it can be concluded that the summary effect of 38 articles related to the effect of the problem-based learning (PBL) model on the critical thinking skills of junior high school students as a whole is 0.805 with a very large category. In addition, the amount of the summary effect of the influence of the problem-based learning (PBL) model on the critical thinking skills of junior high school students in terms of class levels, namely in class VII, a summary effect value of 0.380 is obtained in the medium category, for class VIII it produces a summary effect value of 0.662 classified as a large category, and class IX is in a very large category with a summary effect value of 1.793. From these data it can be concluded that the grade level that has the highest average effect size is grade IX. So from these results it can be said that the Problem Based Learning (PBL) learning model affects the critical thinking skills of junior high school students in mathematics.

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