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META-ANALYSIS OF THE EFFECT OF APPLYING PROBLEM BASED LEARNING MODEL ON KNOWLEDGE IN PHYSICS LEARNING

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ABSTRACT

The development of education is one aspect that must always consider. One of the endeavors to raise educational standards is to develop the curriculum. The real conditions obtained after conducting the analysis showed that the learning model applied was conventional, which resulted in low learners' learning outcomes. One solution to this problem is to use a paradigm of problem-based learning (PBL) in physics learning. Meta-analysis research systematically examines statistical techniques by combining the results of several previous studies to determine the overall conclusions. The investigation intends to ascertain the application models of PBL have an influence in physics learning. This method examines some results from several articles on similar problems. This method accumulates the impact of insignificant article results into a significant result. The results obtained from the meta-analysis method can answer the gaps in the results of various articles with similar problems. The research results revealed that PBL Model are being used in physics learning as a whole has an influence and is suitable to apply in learning with an effect size of 1,154. PBL Model significantly influence the class level, subject matter units, concept understanding skills, critical thinking, creative thinking, and solution to problem. This article's conclusion study is to apply the PBL model in physics learning more effectively to improve the knowledge aspect of learners.

Keywords :*Meta-Analysis; Physics Learning; Problem Based Learning; Aspects of Knowledge.*

I. INTRODUCTION

In the 21st century, the development of science and technology has become one of the challenges to improve human resources more creatively and innovatively. Human resources are required to master and respond to the advancement of science and technology, where science and technology have a very close relationship with the world of education. One of the government's efforts to improve the quality of education is to innovate, such as the development of curricula that can improve the implementation of educational procedures in schools. The 21st century curriculum requires learners to have the ability to think critically, think creatively, the ability to communicate with other learners, and have the ability to collaborate in the learning process. Learning is the interaction of learners with educators, and learning resources in a learning environment result in a learning process[1].

The learning process at the level of educational units according to Permendikbud No. 22 of 2016 is held interactively, inspiringly, and fun in order to motivate students to play a more active role and provide sufficient space for initiative, creativity, and independence and psychological physical development of students. One of the subjects that can develop learners' thinking skills in solving problems related to events that occur everyday and can develop the knowledge and skills of learners, namely physics subjects.

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Physics is one of the subjects in the natural science family that can develop learners' thinking skills in solving problems experienced in real life. Physics is a science that seeks to understand the rules of nature that are so beautiful and neatly describe them systematically[2].

Physics learning is learning whose principles of the learning process are active learning where learners get the opportunity to develop their potential[3]. Physics learning is learning that teaches learners to have scientific attitudes and methods in producing scientific products. This scientific product is in the form of concepts, principles, principles, laws, and theories of physics. The purpose of the physics learning process is not determined from understanding concepts alone but also seen from the higher-order thinking skills of learners[4].

The problem that occurs in real conditions is in the teaching-learning process using conventional models that tend to be dominated by teachers who act as presenters of information during the learning process that cause learners to become bored, passive, independent, and uncreative[5, 6]. Teachers emphasize solving problems with formulas so that learners can only count without understanding the actual concept of physics that makes learners think physics is difficult and boring[7, 8]. Learners' curiosity towards the physics matter is still low. They prefer to memorize rather than analyze problems that cause learners to feel confused when faced with new material so that they cannot lend the material learned in everyday life[9]. One solution to the problems described above is to apply the PBL model in the physics learning process.

PBL is an inquiry method that seeks to answer a question or more, curiosities, doubts, and uncertainties regarding complex living occurrences. Any doubt, difficulty, or ambiguity that invites or necessitates a solution is referred to as a problem[10]. The PBL problem is a type of learning that promotion to students to be more engaged and productive critical thinking skills to locate real-life problem solutions that challenge learners' abilities and provide satisfaction in finding new knowledge for learners[11, 12]. PBL presents a variety of authentic and meaningful problem situations to students who serve as a stepping stone for investigation and investigation[13]. The PBL model was chosen because the PBL model requires learners to be active in the learning process. That aims to solve problems related to real experiences that they encounter directly in everyday life.

Meta-analysis is a statistical approach that was designed for aggregate quantitative results from previously published some the same studies[14]. Meta-analysis research is a study that uses the dimensions of the magnitude of influence or effect size of the results of research that have been combined for analysis. Effect size is the difference in effect events between the experimental and control groups[15]. Effect size statistics result in statistical standardization of research findings so that the resulting numerical values can be consistently analyzed in all variables involved in the study[16]. The purpose of research with meta-analysis methods is no different from the type of research in general. First, to obtain an estimate of the effect size to determine the strength or difference in relationships between variables. Second, inference from the data in the sample to the population by testing hypotheses and estimates. Third, control over variables that can be a role so as not to interfere with statistical and relationship or difference[17].

II. METHOD

This study employed the following research method is a meta-analysis method which is a descriptive research method. Meta-analysis is quantitative because it uses a lot of data and applies statistical methods to compile a certain amount of information from a set of articles with a lot of data. The study reviewed 23 articles that included international articles and national articles. The criteria of the article used are (1) examining the impact of PBL approaches in physics education, (2) articles at the high school education level, (3) have information that supports meta-analysis research, (4) accredited and reputable articles, (5) published from 2013 to 2021. The meta-analysis research procedure is (1) establishing the research theme, (2) determining the type of publication, (3) gathering research findings, (4) recording research data, and (5) determining the extent of the influence per source, (6) making a report. The equation for calculating effect size values[18]:

a. The effect size formula for the comparison test of two samples is related to the average pretest-posttest value and the known pretest-posttest standard deviation is:

$$d = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{within}}$$

$$SD_{within} = \sqrt{\frac{{SD_{pre}}^2 - {SD_{post}}^2}{2}}$$

b. The Effect size formulas for the average posttest pretest value, the pretest standard deviation, and the standard posttest deviation of the control group is known to be:

$$d = \frac{(\bar{X}_{post} - \bar{X}_{pre})_E - (\bar{X}_{post} - \bar{X}_{pre})_C}{SD_{within}}$$

$$SD_{within} = \sqrt{\frac{(n_E - 1)SD_{pre\,E}^{\;2} + (n_C - 1)SD_{pre\,C}^{\;2} + (n_E - 1)SD_{post\,E}^{\;2} + (n_C - 1)SD_{post\,C}^{\;2}}{2(n_E + n_C - 2)}}$$

c. The effect size formula for the comparison test of two free samples and for the number of students in the experimental group and the number of students in the control group, and the known t_h values are:

$$d = \frac{\bar{X}_E - \bar{X}_C}{SD_{within}} \qquad d = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$$

$$SD_{within} = \sqrt{\frac{(n_E - 1)SD_E^{\;2} + (n_C - 1)SD_C^{\;2}}{n_E + n_C - 2}}$$

Description:
ES = Effect Size Cohen's
X_{postE} = Average posttest of experimental group
X_{preE} = Average pretest of experimental group
X_{postC} = Average posttest of control group
X_{postC} = Average pretest control group
SD_{preE} = Standard deviation pretest experimental group
SD_{postE} = Standard posttest deviation of experimental group
SD_{preC} = Standard pretest deviation of control group
SD_{postC} = Standard posttest deviation of control group
SD_{within} = Standard d combined eviation of
n_E = Number of experimental groups
n_C = Number of control groups
t = Value t calculated

Table 1 shows how the effect size results are translated into effect size criteria.

Table 1. Effect Size (ES) Criteria

No	ES	Category
1	ES ≤ 0,15	Can be ignored
2	0,15 < ES ≤ 0,40	Low
3	0,40 < ES ≤ 0,75	Medium
4	0,75 < ES ≤ 1,10	High
5	ES > 1,10	Very high

(Source: [19])

III. RESULTS AND DISCUSSION

A. Research Result

The results of the research obtained from coding data that have been made aim to find out the value of the effect size of the influence of problem-based learning models on the ability to understand concepts, critical thinking skills, creative thinking skills, and problem-solving skills. In addition, it is also to find out the effect size value based on the level of the class, and the unit of subject matter.

1. Effect Size Influence of PBL Model in Overall Physics Learning

The first analysis is related to the value of the effect size influence of PBL model in overall physics learning. The mean effect size value obtained from each article is processed with summary the size of the effect the random effect model. Summary analysis of PBL model influence in physics learning as a whole presented in Table 2.

Table 2. Data Results Mean Effect Size PBL Model in Overall Physics Learning

N	ES	SE	Category	*P*	95% Confidence Interval	
					Lower	Upper
23	1,154	0,138	High	0,000	0,888	1,420

The first research result is influence of PBL model in overall physics learning. The results of the mean effect size analysis obtained by 1,154 which shows that the treatment of PBL models has a large and meaningful influence in physics learning. Students differ significantly who are taught using PBL model with conventional learning model[20].

2. Effect Size Influence of PBL Model in Physics Learning Based on Class Level

The second analysis is related to the value of the effect size influence of PBL model in physics at the class level. The articles analyzed are physics learning articles that use PBL model at the education level of High School and Madrasah Aliyah. There are 13 articles of physics subject matter class X and 10 articles of physics subject matter for class XI. The mean effect size value obtained from each article is processed with summary effect size using the random effect model. Effect size analysis results of the PBL model influence physics learning based on the class level presented in Table 3.

Table 3. Effect Size the Impact of the PBL Model in Physics Learning Based on Class Level

Class Level	N	ES	SE	Category	*P*	95% Confidence Interval	
						Lower	Upper
X	13	0,996	0,174	High	0,000	0,654	1,338
XI	10	1,268	0,213	Very High	0,000	0,951	1,786

The analysis results of the mean effect size value obtained for class X level is 0,996, which belongs to the high category, and for class XI level, which is 1,268, which belongs to the very high category. Mean effect size scores at both levels of the class have a big impact. The shows that the PBL model is worth using in physics learning. Differences in influence at both levels of the class have a relationship with the cognitive development of children who psychologically learners at the level of class XI are at a stage that begins to be able to think abstractly independently, logically, more scientifically in thinking[21].

3. Effect Size Influence of PBL Model in Physics Learning Based on Subject Learning Material

The third analysis is related to the value of the effect size influence of PBL models in physics learning based on subject matter units. The subject matter unit consists of thermodynamics, fluid mechanics, classical mechanics, and electrodynamics. The mean effect size value obtained from each article is further processed with summary effect size using fixed effect and random effect models. Summary effect size analysis of PBL model influence in physics learning based on subject matter units presented in Table 4.

Table 4. Data Results Mean Effect Size PBL Model in Physics Learning Based On Learning Material

Learning Material	N	ES	SE	Category	*P*	95% Confidence Interval	
						Lower	Upper
Thermodynamics	2	0,753	0,175	Medium	0,000	0,410	1,097
Fluid Mechanics	7	1,359	0,116	High	0,000	1,131	1,586
Classical Mechanics	11	1,109	0,214	High	0,000	0,689	1,529
Electrodynamics	3	0,787	0,320	Medium	0,000	0,160	1,413

The third study result is effect of problem-based education models in physics learning based on the unit of learning material. Based on all units of material analyzed, the highest mean effect size value is in the unit of fluid mechanics material with a value of 1,359. This mean effect size value shows that the application of problem-based learning models is most influential in physics learning in the material units of fluid mechanics. The is because the fluid material unit is a unit of matter close to real life. Many of the frequent events in everyday life use the principles of fluid matter[22]. Therefore, it can say that the use of PBL Model has a significant influence on the units of physics subject matter.

4. Effect Size Influence of PBL Models in Physics Learning Based on Bound Variable

The fourth analysis is related to the value of the effect size influence of PBL model s in physics learning based on bound variables. The bound variables analyzed are understanding concepts, critical thinking skills, creative thinking skills, solution to problem skills, and learners' mastery in aspects of knowledge. The mean effect size value obtained from each article is further processed with summary effect size using fixed effect and random effect models. Summary effect size analysis results of models of PBL based on physics lessons on bound variables present in Table 5.

Table 5. Data Results Mean Effect Size PBL Model in Physics Learning Based on Bound variable

Bound Variable	N	ES	SE	Category	*P*	95% Confidence Interval	
						Lower	Upper
Concept Understanding	4	1,508	0,429	Very High	0,000	0,667	2,349
Critical thinking	6	1,025	0,266	High	0,000	0,503	1,546
Creative Thinking	2	2,014	0,457	Very High	0,000	1,118	2,911
Solution to problem	10	0,807	0,133	High	0,000	0,546	1,067

The survey's findings analysis of the mean effect size value contained in Table 5 showed the most influential bound variable, namely the ability to think creatively. At the same time, the lowest on bound variable is in the aspect of knowledge. The model of PBL has the greatest the influence of the variable creative thinking ability of 2,014, which falls into a very high category. This study shows that learning that applies PBL model is effective at enhancing learners' creative a comparison of thinking abilities to using conventional models. The mean effect size value shows that the use of the PBL model is most influential in physics learning on learners' creative thinking skills. PBL Model bring out aspects of creative thinking skills: always being curious, having broad interests, and doing creative activities. It is very influential in training learners in creating new ideas or ideas.

B. Discussion

This meta-analysis research aims to determine the influence of the use of problem-based learning models on aspects of knowledge in physics learning that are seen based on several bound variables and moderator variables that have been established. To find out the influence given by the problem based learning model, an effect size calculation is carried out so that it can be assessed and evaluated the results of the study.

The first research result is the influence of the use of problem-based learning models on aspects of knowledge in overall physics learning. The results of the analysis of the mean effect size value obtained by 1,154 showed that the treatment of problem-based learning models had a very large and meaningful influence in physics learning. The mean effect size value also gives the meaning that the problem based learning model is very effective for use in the physics learning process.

The second research result is the influence of the use of problem-based learning models on aspects of knowledge in physics learning based on class level. The results of the analysis of the mean effect size value obtained for the X class level are 0.996 which belongs to the high category and for the class XI level, which is 1,368 which belongs to the very high category. The mean effect size at both levels of the class exerts a great influence. This shows that problem-based learning models are feasible to use in physics learning.

The results of the third study are the influence of the use of problem-based learning models on aspects of knowledge in physics learning based on units of subject matter. The results of the analysis of the mean effect size value obtained by each unit of subject matter are different. The results of the analysis showed that the problem-based learning model applied to the material units of fluid mechanics and classical mechanics belongs to the very high category, while for thermodynamic and electrodynamic material units belong to the high category, so the units of physics subject matter on fluid mechanics and classical mechanics are highly recommended to apply problem based learning models in the learning process.

The fourth research result is the influence of the use of problem-based learning models on aspects of knowledge in physics learning based on the level of thinking ability. From all the articles, four groups of thinking skills were analyzed. Each group of thinking skills levels has at least three articles to be researched. The results of the analysis of the mean effect size value show the level of thinking ability that has the greatest influence, namely the ability to think creatively with a value of 2,014. While the lowest level of thinking ability is in problem-solving ability with a value of 0.807.

IV. CONCLUSION

The PBL methodology was chosen since it is the most effective requires learners to be proactive in the learning process, and the purpose is to enable learners to solve problems related to the real experiences they directly encounter in their daily lives. The PBL model has a significant impact on overall physics learning. In class X, XI the effect is the largest in class XI. Among the units of learning materials, it has the greatest impact on the material units of fluid mechanics. Inbound variables have the highest impact on creative thinking ability. The conclusion is the fact that the use of the PBL model has been successful a positive impact on *the knowledge aspect of learners.*

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