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META-ANALYSIS OF THE EFFECT OF MODEL PROJECT-BASED LEARNING ON THE LEARNING OUTCOMES OF PHYSICS STUDENTS IN HIGH SCHOOL/VOCATIONAL SCHOOL

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ABSTRACT

This study aims to describe and analyse the effect size of the Project Based Learning (PjBL) learning model on the physics learning outcomes of students in high school/ vocational equivalent, calculated based on (1) sample size; (2) duration of the study; (3) subject matter, and (4) a significant influence on the overall PjBL learning model. This type of research is a meta-analysis which is a form of research using pre-existing data. The research population is a Project-based learning model journal with physics learning outcome variables. Hence, research samples in the form of scientific articles published through google scholar nationally are at the high school/ vocational level in 2015–2022 and use experimental research types with predetermined criteria. The research instrument uses a coding sheet. The result of research from 18 articles showed the influence of PjBL on physics learning outcomes, (1) based on the sample size obtained a sample of 72 people with a value of 1,678 very large categories; (2) based on the duration of the study, it was found that the research for five weeks had a value of 1,648 very large categories; (3) based on the subject matter has the result that the global warming material with a value 1,678 categories is very large; (4) the overall effect size show that the PjBL model affect physics learning outcomes with a medium category of 0.45. This study shows that the project-based learning model can be an alternative to improve the physics learning outcomes of students in high school/ vocational school. However, the effect size in the study varies. Therefore, this research implies that to develop learning to improve student learning outcomes, the project-based learning model can be used to further improvements.

Keywords: Effect size; meta analysis; learning outcomes; project-based learning

1. INTRODUCTION

(Jatmiko et al., 2021:2). Development is increasingly essential for education (Manik & Syahwin, 2018:34). The era of globalisation and the increasingly highly competitive environment make talent and intelligence must be further increased (Habib & Nagata, 2020:1). The need for student understanding related to physics is carried out in various ways, with the hope that the teaching carried out by the teacher can be memorable and student learning feels more meaningful. Thus, adaptability is needed to increase students' mastery of knowledge and new abilities.

Adaptability is quite essential, and this is because the learning process of Physics is still dominated by traditional systems, such as lectures and drills that are not conducive to preparing students to face this increasingly tricky era. One of the problems faced by the world of education is the weak learning process (Latukau et al., 2021: 196). The role of teachers in implementing the teaching and learning process is crucial. Also, the quality of education can be determined by the teacher's ability to choose a suitable model and support the achievement of learning outcomes. (M. A. Jatmiko, A. Hatibe, 2021:24).

On the other hand, Physics learning outcomes are generally still low. Learning outcomes are students' abilities after receiving their learning experience, including cognitive, affective, and psychomotor aspects (Zulmiyetri et al., 2019). So that learning outcomes are the result of an interaction between learning and teaching (Dimyati, 2017). Good learning outcomes can be achieved if teachers develop learning that transfers knowledge to students and assists students in digesting and shaping their understanding with appropriate learning models.

One factor influencing learning is the use of learning methods because it is one effective way to improve student learning outcomes using interesting methods (Qalbi et al., 2017: 106). Therefore, it is necessary to change learning so active teachers are oriented toward active students (Nurfausiah & Suhardiman, 2016: 10). Learning models are essential to learning because they can help educators manage learning. The active learning model has been applied in various fields of Education to increase student engagement and interaction by changing students' learning styles from passive to active learning.

The learning model thought to improve physics learning outcomes is the *Project Based Learning* model. This model uses physics problems as the first step in gaining new knowledge from experience in actual activities. *Project* is the word that distinguishes PjBL from other instructional approaches. It can be defined as "the act of creation over time" (Chen & Yang, 2019: 2). This model can be an alternative because it uses creative and innovative learning that is student-centred *and* places teachers as motivators and facilitators, where students are allowed to work independently or in groups to construct their understanding (Suranti et al., 2017: 73).

Through the PjBL model, students must realize that real-world problems are more than just solving exercises with the correct equations (Izzah et al., 2021:160). Chen and Yang's (2019) review compared the effects of PjBL and teacher-direct teaching on students' academic achievement in primary, secondary, and higher education. The results show that the PjBL model has a more positive impact because students work on authentic projects and product development than direct teaching by teachers (Guo et al., 2020:1).

There are differences in research results based on many similar studies using the *Project Based Learning* (PjBL) model to improve student learning outcomes in Physics learning. Therefore it is necessary to organize data by digging for more information from the studies that have been done. The results of the analysis from this study can later be used to illustrate the effectiveness of the *Project Based Learning* model on learning outcomes in physics learning, and teachers can consider this learning model as one of the effective models that can be used in physics learning.

Starting from several approaches, problems, and conjectures, as stated above, the main study in this study is to analyse the *Project Based Learning* Model and its effect on the learning outcomes of Physics in high school/ vocational school as a whole, both based on sample size, duration of research to the material used.

2. METHODS

The type of research used is a meta-analysis. Meta-analysis is research by researchers by summarising, reviewing, and analysing data from several pre-existing research results(Anugraheni, 2018, p.10). The card states that meta-analysis is a synthesis of several studies that focus on the results found in those studies. This is supported by Hunter and Schmidt, who says that meta-analyses can integrate findings from several studies to reveal patterns of relationships underlying the research literature, thus providing a basis for theory development (Schmidt & Hunter, 2015). Thus, the meta-analysis will provide more quantitative and statistically based conclusions by considering the strength of effect measures in each empirical study evaluated and an aggregate and more accurate view of the studies (Ting et al., 2022:4).

Meta-analysis is done by collecting data through surveys and analysing scientific publications or research journal results. This research sample comprises 18 national-scale research journals and is accessed through *Google Scholar*.

The criteria for sampling research journals are (1) Educational journals that use the *Project Based Learning model* as a treatment related to learning outcomes on physics material; (2) Published in 2015-2022; (3) Carried out in high school / vocational education units; (4) The type of experimental research using two classes, namely the control class and the experimental class; (5) All article information is complete to determine the *Effect Size* contained in the research journal. Data collection techniques in this study were carried out by non-random sampling (*Non-Probability Sampling*) with purposive sampling techniques. *Purposive sampling* is a technique of sampling data sources with specific considerations.

The instrument used in this study is coding data. The variables used in *coding* data to capture information are (1) the Name of the researcher and year of research; (2) the Education level of the research sample; (3) the length of treatment time; (4) the field of science studied; (5) sample size; (6) Research independent variables (*project-based learning* model); (7) Dependent variables (learning outcomes); (8) Have a mean value and standard deviation or have a *calculated t* value; (9) Using experimental research with two. The primary key in meta-analysis research is *effect size* to represent the results of quantitative findings from several studies in a standard form that allows numerical comparison and meaningful analysis of the entire study (Retnawati et al., 2018: 111-115).

$$g = J \times d$$

J is a correction factor and is the *effect size* before the data is converted to g because, according to Hadges, that value d has a slight bias, which tends to produce estimates that are too high or larger (*overestimated* than the absolute value of population parameters. Furthermore, for d, in the formula:

$$d = \frac{\bar{X}_E - \bar{X}_K}{S_{withun}}$$

$\bar{X}_E$ and $\bar{X}_K$ represents the average of samples from two different groups, and S_{withun} is the combined standard deviation with the formula:

$$he\ S_{withun} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 1)}}$$

Where n_1 and n_2 represent the sample size of the two groups, while S_1^2 and S_2^2 are the standard deviations of the two groups, determine *the effect size* using the t-test value, calculated using the following formula:

$$d = \frac{t}{\sqrt{2n}}$$

To determine the magnitude or absence of the *effect size* value, the criteria proposed by Cohen (Gazali, 2017) are used as follows:

1. $(0 < g \leq 0{,}20)$ = Small Effects
2. $(0{,}20 < g \leq 0{,}50)$ = Medium Effect
3. $(0{,}50 < g \leq 0{,}80)$ = Large effect
4. $g > 0{,}80)$ = Very Large Effect

Next, determine the *summary effect,* variance, and *standard error effect size,* then test the hypothesis using a statistical *random effect model* (Retnawati et al., 2018).

3. RESULTS AND DISCUSSION

The Effect of the PjBL Model on Learning Outcomes Based on Sample Size

Table 1. Effect of research sample size

Sample size	Journal code	ES value	Category
40	A15	0,686	Great
47	A9	0,406	Medium
48	A10	0,249	Medium
60	A1	0,336	Medium
	A7	0,219	Medium
	A14	0,32	Medium
	A18	0,177	Small
62	A6	0,156	Small
64	A3	0,791	Large
	A4	0,576	Medium
	A11	1,063	Sangat Besar
	A12	0,285	Medium
69	A13	0,415	Medium
70	A2	0,152	Small
72	A16	1,648	Very Large
75	A8	0,367	Medium
76	A17	0,165	Small
77	A5	0,124	Small

The sample is a portion of the population taken using sampling techniques. The sampling technique used is *non-probability sampling*. *Non-probability sampling* is a technique that only provides equal opportunities for some elements or members of the population to be seen as a sample.

Overall, the average influence of *the Project-based learning model based on the study's sample size has a medium category; this means that in terms of research sample size,* the Project-based learning model can improve learning outcomes. These findings show that sample size is one factor determining the effectiveness of the influence of *Project-based learning models* in physics learning.

Based on the analysis results, as presented in Table 1 regarding the effect of sample size, research shows that each journal has a different number of samples. Thus, these findings show that the highest average influence is achieved when the sample size is 72 people. The sample size was 72 people with *an effect size* of 1,648 with a large category. This data provides the greatest average influence compared to other sample sizes. This means that a sample size of 72 people is the most effective compared to other sample sizes.

The difference *in effect size of* each sample size can be influenced by other factors such as the duration of the research and the material applied in the research process. This means that the sample size is not the main determinant of treatment effectiveness. This is in Djaali's opinion that "the sample size is determined by several factors, namely: the degree of diversity, the desired precision of the researcher, the analysis plan, as well as labor, cost, and time." (Kadir. et al., 2014).

Statistically, it is stated that the larger the sample size, is expected to give better results. Although a large sample will be better, a small sample, when randomly selected, can accurately reflect the population (Hajar, 1996:147). So important is sample quality so that research results are considered worthless if the sample used does not meet the requirements for accuracy, validity, and reliability (Abadi, 2006 :140).

Thus, this study shows that the research sample size or the number of students who follow learning with the *Project Based Learning* model does not determine the influence given to student physics learning outcomes. This refutes the argument that the more sample sizes taken when applying learning with the *Project Based Learning learning model*, the greater the influence will be given. From all the explanations above, the sample size does not have an important effect in determining the size of the *effect size*.

The Effect of the PjBL Model on Learning Outcomes Based on Research Duration

Table 2. Effect of study duration

Duration of study	Journal code	ES value	Category
2 weeks	A14	0,320	Medium
1 month	A3	0,791	Large
	A5	0,124	Small
	A6	0,156	Small
	A7	0,219	Medium
	A8	0,367	Medium
	A9	0,406	Medium
	A11	1,063	Very Large
	A12	0,285	Medium
	A15	0,686	Large
	A1	0,336	Medium
5 weeks	A16	1,648	Very Large
6 weeks	A10	0,249	Medium
	A18	0,177	Small
2 month	A4	0,576	Large
1 semester	A2	0,152	Small
	A17	0,165	Small
2 years	A13	0,415	Medium

The duration of the study, or can also be called the research time, is the time researchers use to conduct research carried out since the date of issuance of the research permit.

Based on the results of the analysis shows that several journals have the same length of research. The average influence of the *Project-based learning* model from the highest to the lowest in a row is five weeks, two months, one month, two years, two weeks, six weeks, and one semester. Thus, the length of treatment of 5 weeks gives the most significant effect on average compared to others.

Treatment for five weeks with an average *effect size* of 1,648 with a large category. This data has the highest moderate influence on learning outcomes in physics learning. This finding states that the length of treatment for five weeks is more effective. The diversity of the considerable impact on the 5-week study indicates that in some treatments, there was a difference in the average of the experimental and control groups too small or vice versa to be less consistent. The findings of this study are similar to Kadir's, where intervals of 2-6 weeks tend to have an optimal average influence.

The Effect of the PjBL Model on Learning Outcomes Based on Subject Matter

Table 3. Influence of research material

Subject matter	Journal code	ES value	Category
SHM	A1	0,336	Medium
	A18	0,177	Small
GW	A16	1,648	Very Large
Fluid	A7	0,219	Medium
	A8	0,367	Medium
	A9	0,406	Medium
	A15	0,686	Medium
EPI	A12	0,285	Medium
DE	A6	0,156	Small
Physics	A2	0,152	Small
	A3	0,791	Large
	A4	0,576	Large
	A5	0,124	Small
	A10	0,249	Medium
	A11	1,063	Very Large
	A13	0,415	Medium
	A14	0,32	Medium
	A17	0,165	Small

Information:

SHM = Simple Harmonic Motion
EPI = Electric Power Installation
GW = Global Warming
DE = Dynamic Electricity
SM = Straight Motion

Effective learning needs to be supported by a good learning atmosphere and environment, so teachers must be able to process students, form learning activities, process materials, and learn resources. The term learning model can also be termed as a learning strategy, where the learning strategy is a set of selected policies, which have been associated with factors such as lesson material, presentation of subject matter, how to present subject matter, and target recipients of subject matter.

Based on the table, it can be seen that each journal has different materials, and some are the same. The category of each material can be seen in the table. It is said that simple harmonic motion material has a medium category, global warming material in the large category, fluid material is in the medium category, electric power installation material is in the medium category, dynamic electric material is in a small category, and for physics, the material is in the medium category.

The results of the analysis presented in the table show that the average influence of the *Project Based Learning* model from the highest to the lowest in a row is on the subject matter of global warming, then physics, fluids, electrical power installations, simple harmonic motion, and finally dynamic electricity. The effect *size* on global warming was 1,648 in the large category.

In learning, the need for models can increase student interest, and the main goal is improving student learning outcomes. An interesting thing that needs to be understood again from the research above is that the great and low average influence of treatment can occur due to the specificity of the field of science or material. In the field of physics, some materials are suitable for the *Project-based learning* model, but some materials could be better for the model. Therefore, it is necessary to adjust the material to the model you want to apply in learning. From the explanation above, the *Project Based Learning* model can improve student learning outcomes if applied to appropriate material because an ideal learning process is to increase student learning outcomes.

The Effect of the PjBL Model on Overall Learning Outcomes

More than 190 journal experimental research reports discuss the *Project Based Learning* model in the 2015-2022 research period. The data is obtained from search results on *google scholar.* After a thorough analysis of around 190 journals, only 18 journals met the research criteria.

The data obtained from the research on the influence of *the Project-based learning* model with experimental studies analysed amounted to 18 articles published by the research criteria that had been diagnosed. The summary of the *value of effect size (ES)* and *the standard error* of effect *size* can be seen in the table, which has been grouped into several categories.

Table 4. Effect size *calculation results*

Journal code	Researchers	ES	SE
A1	Rosviana al. (2018)	0,336	0,258
A2	N Khoiril al. (2016)	0,152	0,238
A3	Almutia al. (2015)	0,791	0,258
A4	Azwar et al. (2016)	0,576	0,254
A5	Irham al. (2015)	0,124	0,227

A6	Betty al. (2016)	0,156	0,253
A7	Siti .al	0,219	0,257
A8	Jonathan .al (2017)	0,367	0,232
A9	Pintor .al (2015)	0,406	0,293
A10	M.A Jatmiko et al. (2022)	0,249	0,287
A11	Winda dkk	1,063	0,266
A12	Arif al. (2021)	0,285	0,25
A13	Tantawi et al. (2016)	0,415	0,242
A14	Utari et al. (2016)	0,32	0,258
A15	Muliana et al. (2021)	0,686	0,323
A16	Akhmad et al. (2015)	1,648	0,272
A17	Prio et al. (2015)	0,165	0,229
A18	Desi et al. (2019)	0,177	0,257
Average		0,452	0,259

Table 4 shows that of the 18 journals that have been analysed, five journals have *effect size values in the small category, eight* journals have effect size values in the medium category, three *journals with large category effect size values, and two journals with* very large *category* effect *sizes*.

Based on the table, it was found that 18 journals of research results analysed showed the influence (*Effect* size) of the *Project Based Learning* model on different physics learning outcomes, so a presentation was needed to see the overall category of research results. The percentage of *effect size (ES)* values from the table can be seen below.

Table 5. Percentage Effect size

ES Range	f	%	Category
0 < g ≤ 0,20	5	28%	Small
0,20 < g ≤ 0,50	8	44%	Medium
0,50 < g ≤ 0,80	3	17%	Large
g > 0,80	2	11%	Very large

The table results show that the medium category has a larger presentation of 44% than the other categories, with several journals with a medium category effect size of 8. Thus, 18 journals analysed show the effect of effect size with the medium category.

Based on the effect size *calculation results on* the 18 articles obtained, it is known to be in the medium category with a *mean effect* value of 0.452. This figure shows that the average value of student learning outcomes in the experimental group is higher than the control group. This indicates that the *Project Based Learning* (PjBL) model influences efforts to improve student's learning outcomes in high school / vocational school.

After obtaining the effect size data of each journal article, proceed to calculate the *summary effect*. This study used JASP software to get *summary effect* values, heterogeneity test results*, forest plots*, and *publication bias* analysis. The data inputted in JASP software is effect *size (ES) and* standard error of effect size *(SE) data obtained from the calculation results using* Microsoft Excel.

Table 6. Statistic *random effect model*

Mean and precision		
Mean effect	M	0,440
Estándar error	SE_M	0,090
Confidence intervals		
Lower limit (95%)	LL_M	0,246
Upper limit (95%)	UL_M	0,616
Test of the null that M=0		
Z for the test of the null	Z	4,904
p-value	p	<0,001

This is reinforced by research from Iszur et al., that learning outcomes using PjBL can positively influence student learning outcomes (Fahrezi et al., 2020). In addition, a study conducted by Nurul Izzah. et al. that the research results on the influence of the PjBL learning model are effectively integrated to improve student learning outcomes, including knowledge, skills, and attitudes (Izzah & Mulyana, 2021).

The advantages of PjBL which can nurture students by getting used to applying knowledge, attitudes, and skills that are practical and useful for daily life, increase their learning motivation, and can overhaul the mindset of students to be broad, and they can solve the problems faced.

Based on the results of calculations with a random effect model, research findings obtained a summary effect of 0.440, included in the medium category, with a confidence *interval of* 95% ranging from 0.246 to 0.616. This is also reinforced by the result Z = 4.904, with a *p-value* of less than α (0.05). Since *p-value* = 0.001 < α (0.05), H0 is rejected. In other words, *the actual effect size* is not equal to 0. Thus, the physics learning outcomes of equivalent high school students after being taught with *the Project-based learning model are better than those taught without the* Project-based learning model, *so this model is said to be effective for physics learning outcomes. However, in research, there are various limitations.*

The overall *effect size produced in the meta-analysis study on the influence of the* Project Based Learning *(PjBL) model on physics learning outcomes is included in the* medium category but still has some limitations when conducting this meta-analysis research. The research analysed in this meta-analysis is experimental research, which is primarily quasi-experimental, where *quasi-experimental* research does not involve researchers directly when the analysis is applied, so researchers cannot control other variables that can interfere with and affect treatment. Due to the possibility of extraneous variables, this meta-analysis is reported and analysed carefully. In addition, when coding for articles found to be surjective, in other words, only the researcher himself is coding, which ultimately has no reliability between coders.

The research sampled only consisted of a few journal articles from the many research articles obtained. Sampling techniques use *purposive sampling* so that it is not possible to make more comprehensive generalisations. So if there is a generalisation to the meta-analysis, it needs complete accuracy, especially on the same characteristics in the research used as an analysis t-test.

Although there are weaknesses and limitations, as previously stated, the results of this meta-analysis have revealed that the *Project Based Learning* (PjBL) learning model can improve student learning outcomes in the experimental group higher with *effect size values* in the medium category.

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