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Project-Based Learning in Science Education: A Meta-Analysis Study

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Abstract: Project-based learning model is one model that is widely used in science learning. Based on this, the relevant literature was reviewed for the Identification of the Effects of Science-Based Learning Project (physics, chemistry, biology, and science) at all levels of education, starting from elementary, junior high, high school, and university levels. Procedures performed; (1) searching and collecting national and international articles through google scholar (2) determining articles according to the characteristics and research criteria, (3) classifying and categorizing articles according to research variables (4) analyzing the pretest and post-test data of articles. This study examines the findings of 25 articles conducted through a meta-analysis to be able to provide conclusions on the effect of project-based learning models in science learning. The magnitude of the influence of PBL in science learning is 1.67 with a high category according to Cohen. This means that the project-based learning model is effectively applied in science learning.

Keywords: project-based learning, meta-analysis, science education.

Abstrak: *Model pembelajaran berbasis proyek merupakan salah satu model yang banyak digunakan dalam pembelajaran IPA. Berdasarkan hal ini, literatur yang relevan ditinjau untuk mengidentifikasi pengaruh Pembelajaran Berbasis Proyek di bidang IPA (fisika, kimia, biologi, dan sains) pada semua jenjang pendidikan, mulai dari jenjang SD, SMP, SMA, dan Perguruan Tinggi. Prosedur yang dilakukan; (1) pencarian dan pengumpulan artikel nasional dan internasional melalui google schoolar (2) menentukan artikel yang sesuai dengan karakteristik dan kriteria penelitian, (3) mengelompokkan dan mengkategorikan artikel sesuai dengan variabel penelitian (4) menganalisis data pretest dan posttest artikel. Penelitian ini mengkaji temuan dari 25 artikel yang dilakukan melalui meta-analisis untuk dapat memberikan kesimpulan dari pengaruh model pembelajaran berbasis proyek dalam pembelajaran IPA. Besarnya pengaruh PBL dalam pembelajaran IPA sebesar 1,67 dengan kategori tinggi menurut Cohen. Artinya model pembelajaran berbasis proyek efektif diterapkan dalam pembelajaran IPA.*

Keywords: *pembelajaran berbasis proyek, analisis meta, pendidikan IPA.*

INTRODUCTION

Science is a subject at the Elementary School, Middle School, High School, and University levels. At the time of independence, science was called exact science, which later changed to science for elementary level (Al Tabany, 2019) is the mastery and ownership of scientific literacy (students) which helps students understand science in a broader context-process-content, especially in everyday life (Fatmala, Sujana, & Maulana, 2017). Curriculum in science subjects must be able to grow students' self-confidence, learning about science must be accompanied by the development of

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scientific attitudes and skills, learning science should make students able to use their knowledge to understand natural events that are around, learning science must be able to develop "Science process skills" (Fitariya, 2018). Based on the description of science learning in the future science curriculum, it will focus on developing scientific attitudes, scientific skills, reasoning abilities, the ability to carry out scientific investigations, science process skills, and self-confidence, and all of them are oriented towards science literacy.

Science learning is learning that can develop students' scientific attitudes, not only as a product but also as a process in understanding nature (Samatowa, 2010). Science learning must focus on the process (Rahmasiwi, Santosa, & Sari, 2015) and learning outcomes so that the resulting learning will be more meaningful for students. science learning that involves students directly through the learning experiences found in the learning process. students are active in the process of scientific inquiry and contribution to scientific learning (Arena, 1996). Entering the industrial revolution 4.0, learning must master science and technology simultaneously (Anggreni, Jampel, & Diputra, 2020). The success of learning will have an impact on the progress of a nation. Science learning is learning that has an important role in honing students' abilities needed to deal with these developments. Therefore, a learning model is needed that can facilitate the development of 21st-century skills. One of the suitable learning models in the 21st century is project-based learning.

Project-based learning is a learning model that is widely used in science learning. Project-based learning has the advantage of being able to improve students' scientific literacy skills (Afriana, Permanasari, & Fitriani, 2016; Anggreni et al., 2020; Lutfi, Azis, & Ismail, 2018) and student inquiry, problem-solving skills (Dewi, Khoiri, & Kaltsum, 2017), critical thinking (Ahlam & Gaber, 2014; Astuti, Toto, & Yulisma, 2019; Pratama & Prasyaningrum, 2016), creative thinking (Antika, 2017; Dewi et al., 2017; Furi, Handayani, & Maharani, 2018; Lutfi et al., 2018; Uswatun Chasanah, Khoiri, & Nuroso, 2016), independent learning (Susilowaty, 2020), creating learning which means creating a more interesting learning atmosphere and increasing students' enthusiasm and motivation in learning. Project-based learning requires students to be more active in science learning and is collaborative (Birgili, 2015). There are many advantages of PBL in science learning, so researchers are interested in studying how much effective project-based learning is in improving students' abilities and the quality of science learning.

METHOD

This research is a meta-analytic study by reviewing several articles. Data were obtained from articles relevant to the influence of project-based learning models in the 21st Century in science learning at the elementary, junior high, high school, and university levels. The number of articles analyzed in this study was 25 articles. The data analysis technique used is the descriptive quantitative statistical analysis technique. This analysis has the aim of increasing the statistical value for primary research, getting the effect size value. Effect size is the difference in the incidence of effects between the control class and the experimental class.

The data in this study is secondary data because it is obtained from the results of previous research. Data were collected using documentation techniques. The steps for tabulating data are (1) identification of research variables and entering them in the appropriate column, (2) identification of the t-value of the experimental group, and

control group data for each research subject to obtain the effect size. Determining the magnitude of the effect or effect size can use statistical parameters (Bekcer & Park, 2011). Effect sizes can be categorized at levels as shown in Table 1.

Tabel 1. Effect size criteria (Cohen, 2013)

No	Effect Size (ES)	Kategori
1	$0 \leq ES \leq 0.2$	Low
2	$0.2 \leq ES \leq 0.8$	Middle
3	$0.8 \leq ES$	High

RESULT AND DISCUSSION

After identifying 25 articles consisting of international and national articles with different variables, the Project Based Learning (PBL) model for science learning can be grouped based on the variables and the calculation of the effect size value of each article. The grouping is based on moderator variables consisting of aspects of knowledge based on education level, learning materials, science learning used. For more details, the description of the articles analyzed can be seen in Table 2.

Table 2. Journal Codes and Effect Size

No	Code Journal	Effect Size	Average Effect Size	Category
1	Journal 1	3.8		
2	Journal 2	0.7		
3	Journal 3	0.14		
4	Journal 4	0.83		
5	Journal 5	1.19		
6	Journal 6	7.09		
7	Journal 7	3.46		
8	Journal 8	0.81		
9	Journal 9	0.83		
10	Journal 10	0.84		
11	Journal 11	3.78		
12	Journal 12	1.11		
13	Journal 13	0.72	1.67	High
14	Journal 14	0.88		
15	Journal 15	0.63		
16	Journal 16	7.32		
17	Journal 17	3.72		
18	Journal 18	0.49		
19	Journal 19	1.46		
20	Journal 20	1.67		
21	Journal 21	0.34		
22	Journal 22	1.46		
23	Journal 23	1.05		
24	Journal 24	0.45		
25	Journal 25	0.83		

Based on Table 2, it can be seen the description of the article and it is found that the effect size of the project based learning (PBL) model on science learning with average effect size of 1.67 high category. articles are identified by 25 articles.

1. The Effect of Project-Based Learning on Science Learning Based on Educational Levels

From the articles analyzed, it was obtained that the average value of effect size based on education level at the elementary, junior high, high school and college levels of 25 education articles obtained data on the calculation of data on each article. The average value of the effect size and the criteria can be seen in table 3.

Table 3. Effect Size Effect of Project Based Learning (PBL) Model on Science Learning Based on Education Level

Educational level	Journal Code	Effect Size	Average Effect Size	Category
Primary School	Journal 11	3.78	1.87	High
	Journal 12	1.11		
	Journal 13	0.72		
Junior High School	Journal 2	0.7	0.94	High
	Journal 9	0.83		
	Journal 10	0.84		
	Journal 14	0.88		
	Journal 19	1.46		
Senior High School	Journal 4	0.83	1.15	High
	Journal 7	3.46		
	Journal 8	0.81		
	Journal 21	0.34		
	Journal 22	1.46		
	Journal 23	1.05		
	Journal 24	0.45		
	Journal 25	0.83		
College	Journal 1	3.8	2.77	High
	Journal 3	0.14		
	Journal 4	1.69		
	Journal 5	1.19		
	Journal 6	7.09		
	Journal 15	0.63		
	Journal 16	7.32		
	Journal 17	3.72		
	Journal 18	0.49		
	Journal 20	1.67		

Based on the analysis of the articles contained in Table 3 regarding the effect of the project based learning (PBL) model in science learning from the level of education, it can be seen that there are 4 levels, namely elementary, junior high, high school and college. At the elementary level consisting of 25 articles with three articles (Anggreni et al., 2020; Murniyati & Winarto, 2018; Wijanarko, Supardi, & Marwoto, 2017) the effect size was 1.87 where this figure was in the high category, it can be said that the use of the Project Based Learning (PBL) Model is effectively used in science learning. At the

junior high school level, there are 5 articles (with an effect size of 0.94 where this number is in the high category, it can be said that the use of the Project Based Learning (PBL) Model is effectively used in science learning.

At the high school level, there are 8 articles consisting of international articles and national articles. Articles at the SMA level from 8 articles found an effect size of 1.15 where this figure was in the high category. At the Higher Education level, there are 10 articles consisting of international and national articles. Articles at the high school level out of 10 articles found an effect size of 2.77 where this figure was in the high category.

2. The Effect of Project-Based Learning Based on Science Learning

The large analysis of the influence of the Project Based Learning (PBL) model based on science learning can be seen in Table 4 below:

Table 4. Effect Size of Project Based Learning on Science Learning

To Learning	Journal Code	Effect Size	Average Effect Size	Category
Critikal Thinking	Journal 1	3.8	1.97	High
	Journal 3	0.14		
Process Skill	Journal 6	7.09	3.94	High
	Journal 7	3.46		
	Journal 12	1.11		
	Journal 13	0.72		
	Journal 16	7.32		
Solution to Problem	Journal 8	0.81	0.81	High
Concept Understanding	Journal 2	0.7	0.86	High
	Journal 9	0.83		
	Journal 10	0.84		
	Journal 14	0.88		
	Journal 15	0.63		
	Journal 19	1.46		
	Journal 21	0.34		
	Journal 22	1.46		
	Journal 23	1.05		
	Journal 24	0.45		
	Journal 25	0.83		
Science Literacy	Journal 4	0.83	2.30	High
	Journal 11	3.78		
Academic Proficiency	Journal 17	3.72	1.96	High
	Journal 18	0.49		
	Journal 20	1.67		

Based on the data in table 4, it is stated that there are 2 articles that are included in learning critical thinking with an average effect size of 1.97 which are in the high category. In learning process skills, there are 5 articles that are included in the PBL model with an average effect size of 3.94 in the high category. Next, there is 1 article that includes the PBL model in problem solving learning with an average effect size of 0.81 which is in the high category.

In learning the concept of understanding there are 11 articles (Rauziani, Yusrizal, & Nurmaliah, 2016) that are included in the PBL model with an average effect size of

0.86 which are in the high category. Learning scientific literacy with the PBL model there are 2 articles (Anggreni et al., 2020; Nusa, 2021) that have an effect size of 2.80 which are in the high category. And finally, there are 3 articles (Bilgin, Karakuyu, & Ay, 2015; Ergül & Kargın, 2014; ramdhani, 2018) on learning academic skills in higher education with the PBL model with an average effect size of 1.96 which is in the high category.

3. The Effect of Project-Based Learning Based on Science Topics

The analysis of the effect of the Project Based Learning (PBL) model based on the material used in learning can be seen in Table 5. Based on table 5, it can be seen that there are 12 articles of science learning material. Of the 12 journal articles, 9 articles on science and physics learning materials belong to the high category and 3 articles of physics material are classified as medium.

Table 5. Effect Size of Project Based Learning Based on Science Topics

Topics	Code Journal	Effect Size	Category
Liquid Pressure	Journal 2	1.69	Medium
Statistics	Journal 5	1.19	High
Heat	Journal 7	3.46	High
Pollution	Journal 9	0.83	High
Chemistry	Journal 15	0.63	Medium
Motion and Change	Journal 16	7.32	High
Basic Electronics	Journal 17	3.72	High
Colloidal Properties	Journal 19	1.46	High
Optical Instruments	Journal 21	0.34	Medium
Static Fluid	Journal 22	1.46	High
Move straight	Journal 23	1.05	High
Momentum and Impulse	Journal 25	0.83	High

CONCLUSION

Effect Size is an important component in the meta-analysis. Effect Size can present information from the summaries of the analyzed journals. The researcher calculated the effect size price using Cohen's formula. The relationship between the variables seen in this study is the relationship between the effect of the project based learning model on science learning, the effect of the project based learning model on education levels, the relationship of the project based learning model on science subject matter,. So in this study it was found that the project based learning model can improve the learning abilities of students in science learning.

The study was conducted to see the effect of the project based learning (PBL) model on science learning by analyzing 25 articles that have been obtained. The article discusses the use of the project based learning model in science learning in terms of education level, material and science learning. The results of this study were reviewed from three aspects. First, it is seen how the effect size has on students' science learning. The second is to see the effect of the effect size based on the material classification in the project based learning model. The third is to see the effect of the effect size based on the classification of education levels in the project based learning model. In the first result, it can be seen the effect size of the project based learning model in terms of

science learning. The second is seen from the classification of project based learning models on science learning in terms of models, levels of education and subject matter.

In the first results, it can be seen the effect of the project based learning (PBL) model on students' science learning. Based on the results of the effect size in the article, it belongs to the medium to high category. Thus, the overall effect size results with the average effect size of the project based learning problem model, which is 1.67 with a high category, it can be concluded that the project based learning (PBL) model is very effective in science learning.

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