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The Effect of the PjBL Model on Students' Critical and Creative Thinking Skills: A Meta-Analysis

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ABSTRACT

Critical thinking and creative thinking are the main components in 21st-century learning, and this is considering the increasingly rapid development of current technological knowledge. These skills are required in finding a solution to a problem being faced, one model that can potentially train critical and creative thinking processes, namely the Project-based learning model. This study aims to analyse the effect size of using the PjBL model on critical thinking and creative thinking in physics learning, based on subjects and class level. The method in this research is a literature study. The data analysis technique used is qualitative analysis with a quantitative approach. The research used is descriptive of the analysis of the results of scientific research publications in national and international journals. The research findings revealed that overall, the various studies conducted had a significant and effective influence on improving students' critical and creative thinking, with the highest effect size overall being 3.14. The PjBL model gives SMA influence with a large effect category. The PjBL learning model produces effect sizes that vary from various grade levels and subjects.

INTRODUCTION

Education in Indonesia currently uses the 2013 curriculum with a paradigm of 21st-century learning. The challenges of the 21st century will become a problem for human civilisation if we do not prepare early. In this century, human resources need to be improved to compete globally. The rapid development of technology is marked by the rise of software applications to meet human needs.

The Indonesian government has adequately prepared for the challenges of the 21st century. Curriculum renewal continues to be carried out according to the needs of students to support their skills in facing the challenges of this century. The 2013 curriculum currently used is designed to meet the 4C skills. 4C skills include critical thinking, creativity, collaboration, and communication (Zubaidah, 2019). 21st-century skills can be trained and developed in school learning.

Critical thinking and creative thinking are two skills needed to answer the challenges of the 21st century. Intervened critical thinking skills will increase students' curiosity (El-Shaer. A., and Gaber, H. 2014). This critical thinking skill fosters curiosity, interest in learning topics, and a sense of wanting to find knowledge on their own by students.

Critical thinking skills can be improved by paying attention to students' epistemological development, encouraging active learning, applying a problem-based curriculum and stimulating student interaction. Critical thinking skills can be trained and developed. This skill allows students to solve problems related to the real world. Critical thinking can be trained by confronting students with real-world problems packaged in learning, such as project-based learning. In project learning, the 4C skills that can be trained again are creative thinking skills.

Creative thinking skills are skills to find truths, problems, ideas, and solutions to these problems (Sheu & Chen, 2014). Some experts direct creative thinking to all cognitive activities individuals use to react to problem objects based on their abilities (Birgili, 2015). Creative thinking skills foster the ability to generate ideas, solve problems, and create something in solving problems. Darmadi (Luthfi et al., 2019) also conveyed a similar opinion, explaining that project-based learning is designed to solve complexly structured problems requiring students to investigate and understand them. Through these problems, students must think critically and creatively in conducting investigations and solving these problems. Project-based learning has great potential to provide learning experiences for students that are more interesting and meaningful.

By collaborating, 21st-century learning focuses on students (Asrizal A. et al., 2018). This century's learning is also by the curriculum in schools. Learning in schools is currently centred on students and can train critical thinking skills and creative thinking. The teacher is only a facilitator. Learning activities that demand active students can improve collaboration skills and project learning.

METHODS

The method in this research is a literature study. The presented meta-analysis is an overview of the effect size or effect size. The journal articles analysed came from several educational studies. Educational research is analysed by influence studies of the Project-Based Learning model on learning science in junior high and high schools on students' critical and creative thinking skills. The results of this literature study research can be used as a consideration for teachers in choosing integrated learning that suits the skills needs of the 21st century.

Meta-analysis is a statistical analysis using quantitative data from individual studies combined to obtain conclusions (Aslikhah, N., 2015). Meta-analysis is a review of literature research on several journal articles. Meta-analysis is quite effective in describing the effect of two or more variables. The conclusion of this meta-analysis is an illustration of the influence between the variables studied. The results of the meta-analysis research can be used as material for further research. This meta-analysis also advises teachers in choosing lessons for the 4C skills.

The steps for conducting a meta-analysis in this study, namely: First, find 20 reputable research journal articles about the effect of project-based learning on students' critical and creative thinking skill competencies; Second, an analysis of the effect size or effect size of the journal article; Third, look for literature references related to similar meta-analytic research; Fourth, analyse the effect of project-based learning on students' critical thinking and creative thinking skills; Fifth, publish research results to the public.

Data processing in this meta-analysis can use several formulas or formulas. The formula used to calculate the effect size (ES) of the influence of the project-based learning model on students' critical thinking and creative thinking skills. The formula used (Becker et al.; K., 2011) namely:

Table 1. Effect Size Formula

No.	Statistics	Formulation	Formula
1.	ES *one group*	$ES = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pre}}$	Fr-1
2.	ES *two groups posttest only*	$ES = \frac{\bar{X}_E - \bar{X}_C}{SD_C}$	Fr-2
3.	ES *two groups pretest and posttest*	$ES = \frac{(\bar{X}_{post} - \bar{X}_{pre})_E - (\bar{X}_{post} - \bar{X}_{pre})_C}{\frac{SD_{preC} - SD_{preE} - SD_{postE}}{3}}$	Fr-3
4.	*Chi-square*	$ES = \frac{2r}{\sqrt{1-r^2}} ; \sqrt{\frac{x^2}{n}}$	Fr-4
5.	T-count	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$	Fr-5
6.	P Value	CMA (*Chomperhensive Meta Analisis Sofeware*)	Fr-6

The value of the effect size can be interpreted into several categories. The effect size categories can be differentiated as follows:
Effect Size Interpretation:
0 - 0,20 = *weak effect* = less category
0,21 - 0,50 = *modest effect* = low category
0,51 - 1,00 = *moderated effect* = medium category
>1,00 = *strong* = high category
(Brown, L. M., & Haun, J.N., 2014).

RESULTS AND DISCUSSION

Results

The research results from this meta-analysis are to see how big the effect size of the influence of the PjBL model is on critical thinking skills and creative thinking. This data was obtained from 20 kinds of Scopuss integrated journals, both national and international. The subjects include Physics, Chemistry, and Biology. The data is also from junior and equivalent high school education unit-level researchers. The value of the effect size of this meta-analysis can be seen in Table 2 below.

Table 2. Collection of effect size values

No	Code	Journal	Journal Category	Skills	ES Formula	ES Value	Cate-gory
1	J1	Permata, dkk, 2018	National	C1	Fr-3	3,14	T
2	J2	Khalifah, 2016	National	C2	Fr-5	1,30	T
3	J3	Chasanah. dkk. 2016	National	C2	Fr-5	1,39	T
4	J4	Putri, dkk. 2016	National	C2	Fr-2	2,41	T
5	J5	Fajrina, dkk. 2018	National	C2	Fr-5	1,36	T
6	J6	Nurfa, dkk. 2020	National	C2	Fr-5	1,31	T
7	J7	Abdullah, dkk. 2016	National	C2	Fr-5	0,76	S
8	J8	Rahim, 2019	International	C1	Fr-2	1,15	T
9	J9	Wulansari, dkk. 2018	International	C1	Fr-5	1,37	T
10	J10	Permata, dkk. 2018	National	C1	Fr-3	1,18	T
11	J11	Putri, Nindi, dkk, 2019	National	C1	Fr-5	2,09	T
12	J12	Maubana, dkk. 2020	National	C1	Fr-5	1,91	T
13	J13	Mutakinati, L., et.al.,. 2018	International	C1		1,82	

14	J14	Yunus, Azwar Alamsyah, et al.,2015	National	C1	Fr-5	2,41	T
15	J15	Hasanah, et al., 2018	National	C1	Fr-5	0,81	S
16	J16	Kusairi. et al., 2018	National	C1	Fr-3	0.85	S
17	J17	Ali. Et al., 2016	National	C2	Fr-5	1,2	T
18	J18	Saptaningrum. 2018	National	C1	Fr-3	0,90	S
19	J19	Hidayat, et al., 2018	National	C1	Fr-5	0,87	S
20	J20	Fajrina, et al., 2016	National	C2	Fr-4	1,38	T

The meta-analysis from national and international journals showed that the 20 research results stated that the PjBL model influenced critical thinking and creative thinking skills. C1 is critical thinking skills, namely journals J1, J8, J9, J10, J11, J12, J13, J14, J15, J16, J18, and J19. These journals show the influence of effect size in the high category. This means the PjBL model is suitable for classroom learning to train critical thinking skills.

In Table 1, it can be seen that creative thinking skills are coded C2. The journals that look at the influence of C2 skills are J2, J3, J4, J5, J6, J7, J17, and J20. The average of the eight journals states that the relationship between the influence of the PjBL model and creative thinking skills is in the high category. This means the PjBL model is suitable and recommended for training creative thinking skills.

The journals collected are Physics learning journals with various kinds of learning materials. Learning materials from the 20 journals come from grades X, XI, and XII. The effect size can be seen in Table 3 below.

Table 3. Effect size for each subject

No	Code	Subjects	Material	ES	Category
1	J2	Fisika	Harmonious Vibration	1,30	T
2	J4		Measurement	2,41	T
3	J7		Motion Dynamics	0,76	S
4	J11		Optical Devices	2,09	T
5	J14		Electricity And Magnetism	2,41	T
6	J19				
7	J20				
8	J5		Static Fluid	1,05	T
9	J15				
10	J16				
11	J6		Dynamic Fluid	1,31	T
12	J3				
13	J13		Temperature and Heat	1,37	T
14	J18				
15	J10			1,18	T
16	J8		Implus- Momentum		
17	J17				
18	J9		Work and Energy	1,64	T
19	J12				

In Table 3, we can see that five journals examine static fluids, three journals on temperature and heat, three journals on impulse-momentum, two journals on energy work, and each journal discusses the material of harmonic vibration, measurement, motion dynamics, optical devices, electricity and magnetism with also high and medium categories. The data shows that the PjBL model is suitable for training critical and creative thinking skills.

The journals taken are national and international. This journal examines the high school education unit. The class level studied was from class X, XI, to class XII. The effect size data can be seen in Table 4.

Table 4. Effect size for each unit based on

No	Code	Education Unit	Grade Lavel	ES	Category
1.	J2	Senior High School	X	1,50	T
	J4				
	J8				
	J9				
	J10				
	J12				
	J17				
2.	J3		XI	1,23	T
	J5				
	J6				
	J7				
	J11				
	J13				
	J15				
	J16				
	J18				
	J19				
	J20				
3.	J14		XII	2,41	T

From Table 4, we get the effect size of the influence of the PjBL model on critical thinking and creative thinking skills in the high category for all grade levels. The average effect size for class X is 1.50 in the high category, class XI is 1.25, and class XII is 2.41 in the high category. This shows that the PjBL model affects training and improving critical thinking and creative thinking skills.

Discussion

The presentation of the discussion section contains substantial meaning for the results of the analysis and comparison with previous findings based on the results of relevant, up-to-date and primary literature studies (about 50% of references from journals exist and are used here). This comparison should lead to differences with previous research findings so that it has the potential to state a contribution to the development of science, according to the benefits promised in the introduction.

CONCLUTION

The results of the meta-analysis concluded that applying the Project Based Learning (PjBL) model in physics learning improved students' critical thinking skills and creative thinking. From the first effect size calculation, the highest effect is 3.14, and the lowest is 0.76. The 20 journals were separated into 3 class levels, namely class X, with an average effect size of 1.50 in the high category; class XI, with an average effect size of 1.23 in the high category; and class XII, the effect size was 2.41 in the high category. Learning using the Project Based Learning model is very influential for high school students to improve critical and creative

thinking skills in learning physics. So, 20 studies found a positive effect of the Project-based learning model on students' critical thinking skills and creative thinking.

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