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Effectiveness of Project-Based Online Learning on 21st Century Thinking Skills of Indonesian Students: A Meta-Analysis Research from 2018-2023

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Abstract: Online learning plays an important role in supporting learning activities between students and teachers. However, there has been no quantitative meta-analysis of the overall effectiveness of Project-Based Learning online-based learning on students' 21st century thinking skills. The purpose of the study was to investigate the effectiveness of project-based learning online learning on the thinking skills of 21st century students in Indonesia. This type of research is a meta-analysis. The meta-analysis analyzed 16 articles published from 201 8-2023. The results of the analysis concluded that project-based online learning has a significant effect on students' 21st century thinking skills with a summary effect or mean effect size (rE = 1.04 High criteria). Furthermore, these findings conclude that the project-based online learning model effectively encourages students' 21st century thinking skills compared to conventional learning models.

Keywords: Effect size; Online learning; Project based learning; 21st century skills

Introduction

21st century skills are an ability that students must have in facing the era of revolution 5.0 society (Duygu, 2023; Öztürk, 2023). 21st century thinking skills train students to think critically, creatively, communicatively as well as collaboratively in learning (Ichsan et al., 2023; Zainil et al., 2023; Illene et al., 2023). 21st century thinking skills have an important role for students in solving problems that occur in life (Özeren, 2023; Jannah & Ragil, 2022; Bircan et al., 2023; Turhan, 2021). Furthermore, 21st century thinking skills help students be active and innovative in learning (Laar et al., 2020; Putra et al., 2023; Ichsan et al., 2023). Students who have 21st-century skills are more skilled in thinking (Sulaiman & Ismail, 2020).

But in fact, 21st century thinking skills in Indonesian students are still relatively low (Munawwarah et al., 2020; Afandi et al., 2019). This can be seen from the ability to think critically and creatively and students' collaboration in learning process activities is still low (Ernawati & Maniarta, 2022; Ritonga et al., 2022). The results of the *Programme for International Student Assessment* (PISA) research conducted by the OECD in 2018 improved 21st century skills in science literacy of Indonesian students obtained a score of 396 ranked 71 out of 78 member countries (Zulkifli et al., 2022; Elfira et al., 2023; Lafifa et al., 2023; Zulyusri et al., 2023; Menggo et al., 2019). The low science literacy of students in learning will affect the thinking skills of the 21st century (Sukmayadi & Yahya, 2020). Research results (Widiyawati et al., 2021; Dewanti et al., 2020; Vebrianto et al., 2020; Mardizal & Tarmizi, 2021) stated that the low

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21st century skills of students are influenced by teacher activities that do not involve active students, teacher-centered learning, low teacher understanding in using technology and learning models that do not encourage students to think 21st century.

Online learning is a learning model that can be accessed online through platforms connected to the internet network (Moore et al., 2011; Keengwe & Kidd, 2010; Smart & Cappel, 2006; Sönmez & Korucuk, 2023; Beruin, 2022; Santosa et al., 2021; He et al., 2022). Online learning helps students' learning process be more creative and innovative which can support growing students' 21st century thinking skills (Novitra et al., 2021; Karatas & Arpaci, 2021). In-person online learning trains creative students in using technology to learn (Wigati et al., 2023; Wright et al., 2023; Kesumaningsari et al., 2022). Furthermore, online learning trains students to learn independently via Smartphones, computers, Tablets and others (Almahasees et al., 2021; Park & Kim, 2021).

Furthermore, *Project-Based* Learning-based online learning is an effective learning model that encourages students' 21st century thinking skills (Wanglang & Chatwattana, 2023; Baran et al., 2021; Muhammad et al., 2021). *Project-based* learning is a learning model that guides students to create a project or product in learning activities (Puangpunsi, 2021; Puspitasari, 2020; Suherman et al., 2020; Putri & Dwikoranto, 2022; Nurhidayah et al., 2021). The results of research by Mursid et al. (2022) project *based* learning model can improve students' creative thinking skills and learning outcomes.

Research Kardoyo et al. (2019), Listiqowati et al. (2022), Yustiana el al. (2022), Khastini et al. (2021), and Santyasa et al. (2021) online learning based *on the project* based learning model is effective in improving students' creative, critical thinking skills, and learning outcomes. Research from outside Indonesia (Yang et al., 2022; Chanthes, 2022; Malkawi, 2022) stated that online learning can help students think critically and motivate students in learning. However, online learning can affect students' confidence and the effectiveness of students' creative thinking in learning (Delita et al., 2022). Being a gap in this study, many studies on online learning have no research describing the effect size of the effectiveness of project-based learning on students' 21st century thinking skills. Therefore, from these problems, this study aims to determine the effectiveness of project-based learning-based online learning on the thinking skills of 21st century students in Indonesia.

Method

Research Design

This study is a type of meta-analysis research. Meta-analysis is a study that collects and analyzes data quantitatively with statistics (Saepuzaman et al., 2021; Oktarina et al., 2021; Razak et al., 2021; Chamdani et al., 2022; Taşdemir, 2022; Ramadhani, 2022). The data in the meta-analysis study are presented in effect size (Yusuf, 2023). Effect size is a quantitative index that describes the magnitude of influence between variables that serves to analyze the results of each study (Xu et al., 2023).

Sampling

The research sample of this meta-analysis journal must be indexed Science and *Technology Index* (SINTA) and Scopus. Sample search keywords" online learning" online learning on 21st century skills", project based learning "project based learning on 22nd century skills" effectiveness of online learning based on *project based learning* on 21st century students' skills". The data selection process is through the *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA) method which consists of *identification, Screening, Eligibility and Include*.

Inclusion Criteria

The inclusion criteria in this meta-analysis are that research must come from journals published in 2017-2023; The research has experimental classes with online learning models and conventional model controls, publications obtained through google databases Scholar, ProQuest, Wiley, ScienceDirect and PLoS ONE; research in Indonesian or English. Furthermore, after conducting an analysis of each study that met the inclusion criteria, the inappropriate research was discarded. Exclusion criteria in research are qualitative research and do not describe complete quantitative data.

Research Procedure

According to Cohen et al. (2007), Borenstein et al. (2009) states that the meta-analysis steps consist of determining inclusion criteria, coding data, conducting heterogeneity tests, calculating the effect size of research data, calculating the summary effect size; testing hypotheses and publication biases.

Data Analysis

Data analysis in the study by calculating the effect size value of each study with the help of JSAP 0.8.5 software. The formula for finding *the value of effect* size and effect *size* criteria in this study can be seen in Table 1.

Table 1. Effect Size Formula

Statistical Data	Formula
Average value on one group	$ES = \frac{\bar{x}_{post} - \bar{x}_{pre}}{SD_{pre}}$
Average scores in each group	$ES = \frac{\bar{x}_{Exsperiment} - \bar{x}_{Control}}{SD_{Control}}$
Mean and Standard deviation values in each group (two groups of posttes-pretest)	$ES = (\frac{(\bar{x}_{post} - \bar{x}_{pre})_E - (\bar{x}_{post} - \bar{x}_{pre})_C}{SD_{preC} + SD_{preE} + SD_{postC}}$
Chi square	$ES = \frac{2r}{\sqrt{1-r^2}}$; $r = \sqrt{\frac{x^2}{n}}$
t-count	$ES = t\sqrt{\frac{1}{n_{experiment}} + \frac{1}{n_{Control}}}$
P-Value	JSAP 8.5.0

Source: Becker & Park in (Khoiri, 2019; Hidayatullah & Wulan, 2022).

Furthermore, if the value of *Effect size* has been obtained, then the results can be known through criteria (Cohen et al., 2007) which can be seen in Table 2.

Table 2. Effect Size Value Criteria

Effect Size	Criterion
0 ≤ ES ≤ 0.20	Low
0.20 ≤ ES ≤ 0.80	Medium
ES ≥ 0.80	High

Source: (Cohen et al., 2007; Borenstein & Hedges, 2009)

Result and Discussion

Results

Table 3. The *Overall Effect Size* Value of the Study

Journal Code	Year of Publication	Table of Contents	N	Effect Size	Criterion Effect Size
AR 1	2020	SINTA	60	0.78	Medium
AR2	2020	Scopus	140	1.40	High
AR3	2021	SINTA	40	1.09	High
AR4	2023	SINTA	30	0.83	High
AR5	2023	SINTA	75	1.20	High
AR6	2023	Scopus	110	0.80	Medium
AR7	2018	Scopus	390	1.28	High
AR8	2020	SINTA	38	0.69	Medium
AR9	2022	Scopus	70	0.90	High
AR10	2023	Scopus	98	1.02	High
AR11	2019	SINTA	140	0.57	Medium
AR12	2029	SINTA	80	0.65	Medium
AR13	2020	SINTA	20	0.86	High
AR14	2021	Scopus	60	0.82	High
AR15	2021	SINTA	24	0.98	High
AR16	2023	SINTA	48	1.14	Medium

Should From a total of 614 studies searched through the Google Scholar database, ScienceDirect, PrpQuest, Wiley and Taylor of Francis obtained 16 studies that met the inclusion criteria. Furthermore, the 16 studies calculated the *effect size* value of each study can be seen in Table 3.

Table 3 Shows the effect size value of the 16 studies analyzed ranging from (0.82 - 1.40) high criteria and (0.57 - 0.80) medium criteria. Furthermore, there are 10 studies indexed by the *Science and Technology Index* (SINTA) and 6 studies indexed by Scopus. The total sample size (N) used was 1423 students. Before testing the research hypothesis, it first calculates the heterogeneity value of each effect size of the study. The results of the effect size heterogeneity test can be seen in Table 4.

Table 4. Heterogeneity Test Results

	Q	Df	p
Omnibus test of Model Coefficients	79.118	1	< 0.001
Test of Residual Heterogeneity	592.140	15	< 0.001

Note: p value are approximate

Table. 5 The Residual Heterogeneity Test Results

	Estimates	Lower Bound	Upper Bound
τ^2	0.361	0.217	0.576
τ	0.461	0.362	0.623
I^2 (%)	97.168	94.110	99.015
H^2	27.188	15.139	34.804

Tables 4 and 5 show that of the 16 studies analyzed, the *effect size* was heterogeneously distributed. The p-value < 0.001; Q = 79.118 and the values of τ or $\boldsymbol{\tau}^2 > 0$ and I^2 (%) = 97.168 are close to 100%. The next step is to calculate the summary effect size or mean effect sized value of the 16 studies analyzed. The results of the summary effect size test can be seen in table 6.

Table 6. Summary Effect Size Test Results

	Estimates	SE	z	p	Lower Boud	Upper Bound
Intercept	1.043	0.156	7.339	< 0.001	0.598	0.870

Based on Table 6, showing the results of summary effect size analysis with *random effect model,* obtained value obtained value (Z = 7.339; 95% CI [0.598; 0.870]). Furthermore, the p-value < 0.001 this concludes that there is a *Project-Based Learning-based* online learning model effective in improving students' creative thinking skills compared to conventional models with a value of r_E = 1,043 high criteria. Next, determine publication bias using the funnel plot which can be seen in Figure 1.

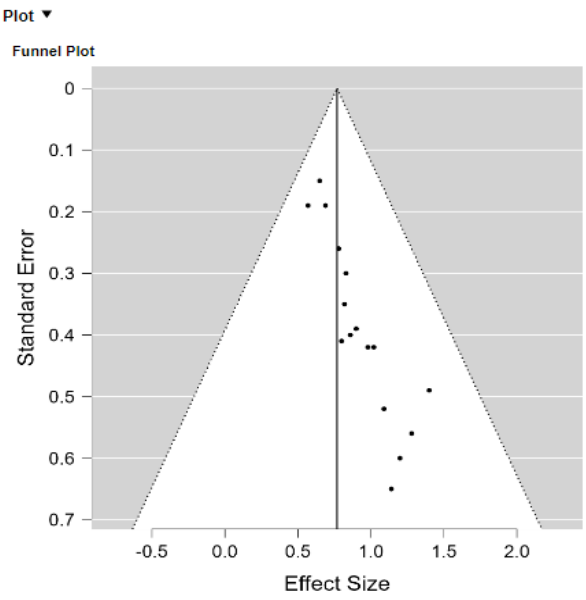

Figure 1. Funnel plot

Based on Table 3, showing publication bias analysis with *funnel plots*, no publication bias has been detected from 16 studies that have been analyzed. Furthermore, to determine symmetrical or asymmetric shaped models, it is necessary to perform the Egger test. Test results can be seen in Table 7.

Table 7. Egger Test Results

	z	p
Sei	0.359	0.450

Based on Table 7, explain that the value of Z = 0.359; p < 0.05 then the funnel plot analysis is symmetrical, so, in this meta-analysis study there is no publication bias from the 16 studies analyzed.

Discussion

From the meta-analysis, 16 studies analyzed explain that the application of *project-based learning* online learning models is effective in improving students' 21st century thinking skills in Indonesia. The results can be seen from the value (p value < 0.001; r_E = 1.043) with the criteria of high category effect size. Research Kong et al. (2014), and Dika et al. (2018), online learning effectively improves 21st century thinking skills in students. Online learning helps students learn more creatively and innovatively in utilizing technology (Watted, 2023; ElçİÇek, 2021; Chung et al., 2020), thus training students to improve 21st century skills. Furthermore, online learning is able to provide unlimited access to learning (Park & Kim, 2021; Daraen et al., 2023; Iqsan & Mardizal, 2021; John et al., 2021).

Furthermore, the application of online learning has a positive impact on the development of students' cognitive patterns in learning (Barrot et al., 2021; Chiu, 2022; Suharyat et al., 2022), which can foster students' interest and motivation in learning. Maqableh et al. (2021) online learning can improve the understanding of learning so that it is easier to understand the subject matter. In addition, *project-based online* learning trains students to think collaboratively, problem solve and be independent in learning (Hendarwati et al., 2021). Research Hasibuan et al. (2022), and Gerh et al. (2020) project-based learning can stimulate students' creative thinking skills and confidence in learning.

Project-based learning leads students to be more creative in producing a product to solve a problem (Maros et al., 2023; Son, 2021; Elfira et al., 2023; Guo et al., 2020). In addition, *project-based* learning can improve students' critical thinking and collaborative skills in learning which are very necessary in facing the 21st century (Wang, 2022; Hussein, 2021; Anazifa, 2017). Therefore, the existence of project-based online learning is a solution for teachers in improving the 21st century skills of students in Indonesia. 21st century skills are essential for students in finding ideas and solutions in solving problems that occur in life (Kholis & Azmi, 2023; Meeuwisse et al., 2023).

Conclusion

From this meta-analysis research, it can be concluded that the application of project-based learning online learning models is effective in improving the thinking skills of 21st century students in Indonesia. The results of the calculation of nila summary effect size or mean effect size from 16 studies analyzed (r_E = 1,043) high criteria. Online learning based on proejct based learning encourages students to be more active and creative in learning. Online learning helps students and teachers learn widely indefinitely. In addition, project-based online learning is very necessary to be applied in the learning process that encourages students' cognitive thinking skills.

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Conflicts of Interest
The authors declare no conflict of interest.

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