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Effectiveness of Online Blended Learning and Critical Thinking Skills of Biology Students in Indonesia: Meta-Analysis Study

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Abstract: This study aims to determine the effectiveness of online blended learning and critical thinking skills of biology students in Indonesia. This type of research is a meta-analysis study. This research data comes from 13 national and international journals. The inclusion criteria of the meta-analysis are publications derived from google Scholar, ScienceDirect, ERIC, Springer, and Pubmed databases, the study has two classes of experiments blended learning and conventional controls, research publications must be indexed by Scopus, SINTA and WOS, research comes from reputable journals or proceedings and sample size (N) > 20 students. Keyword data search consists of blended learning; blended learning on the critical thinking skills of biology students; students' critical thinking skills; Online blended learning. Data analysis calculates summary effect size, heterogeneity test and analyzes publication bias with JSAP application. The results of the study concluded that the summary effect size value (ES = 1.05) criteria was high and the total sample (N = 1070) of students This finding shows that online blended learning effectively encourages critical thinking skills in biology students compared to conventional learning.

Keywords: Critical thinking; Effect size; Meta-analysis; Online blended learning

Introduction

The ability to think critically is an ability that students must have in facing the 21st century (Patandung, 2023; Ichsan et al., 2023; Maison, 2022). Critical thinking is a student's ability to analyze and conclude information to solve a problem (Sutoyo et al., 2023; Alharbi, 2022; Sari et al., 2021). The ability to think critically helps students make decisions carefully and logically (Prihono et al., 2020; Ayuningrum et al., 2015). Umam et al. (2022), that critical thinking skills stimulate students to think at a high level in learning. In addition, in learning biology, students are required to have critical thinking skills (Tuaputty et al., 2023). Critical thinking in biology learning encourages students to be able to solve a problem that occurs in life (Arsih et al., 2021; Alsarayreh, 2021).

But in reality, critical thinking skills in biology learning are still relatively low (Ningsih et al., 2021; Kurniahtunnisa et al., 2016). This can be seen from the results of TIMSS research in 2015 stating that students' critical thinking skills in the field of science support the rank of 36 out of 49 countries (Suryono et al., 2023; Nurtamam et al., 2023; Nasution et al., 2023; Luciana et al., 2023). Furthermore, the results of the 2018 PISA survey showed that Indonesian students' science literacy in critical thinking obtained a score of 396 occupying 71 out of 78 countries (Elfira et al., 2023; Razak et al., 2021; Oktarina et al., 2021). The low critical thinking ability of students in learning biology is due to the inappropriate selection of learning models (Supratman et al., 2021; Maryuningsih et al., 2020; Ridzal et al., 2023; Tamam et al., 2020). Not only that, the biology learning process does not lead students to think critically (Bustami et al., 2018; Setiawati et al., 2023; David & Hafsari, 2015). So,

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there needs to be an effective learning model that encourages students to think critically.

Online blended learning is a learning model that can stimulate students to think critically (Anggraeni et al., 2019; Suana & Raviany, 2019; Habibah et al., 2022). Online *blended* learning is an online learning model that can be done face-to-face (offline) and online (online) via the internet network (Fitriani et al., 2022; Watanapokakul, 2022). The online blended learning model helps students' learning process be more interesting and creative (Brodersen & Melluzzo, 2022). Furthermore, students' blended online learning model is more deeply understanding the content and subject matter (Bordoloi et al., 2021; Lockee, 2021).

Research from Ali et al. (2023), Surjono et al. (2019), and Jou et al. (2016) that online-based learning models can improve critical thinking and student learning outcomes. Lu, (2021) online blended learning can help students more actively and critically solve a problem. Research Suana et al. (2020), Rahmatan et al. (2022), and Marnita et al. (2020) Online blended learning is effective for improving students' critical thinking skills. The gap in this study, there are many studies on online blended learning there has been no research describing the effect of the size of online blended learning on students' critical thinking skills in biology learning in Indonesia. Therefore, this study aims to determine the effectiveness of online bleded learning and critical thinking skills of biology students in Indonesia.

Method

Research Design

This research is a type of meta-analysis research. Meta-analysis is research that collects and analyzes primary data quantitatively with statistics (Günay et al., 2023; Suharyat et al., 2022; Yusuf et al., 2020; Ulum, 2022). The meta-analysis research aims to determine the strength of online blended learning and critical thinking skills of biology students.

Eligibility Criteria

Meta-analysis must have an elgibility criterion for the results of a study (Taşdemir, 2022; Cevik et al., 2022). The eligibility criteria in this study are publications derived from google databases Scholar, ScienceDirect, ERIC, Springer, and Pubmed, the study has two online experiment classes blended learning and conventional control classes, research publications must be indexed Scopus, SINTA and WOS, research comes from reputable journals or proceedings and sample size (N) > 20 students. The process of selecting data sources through the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) method consists of identification; eligibility; Screening; and Included can be seen figure 1.

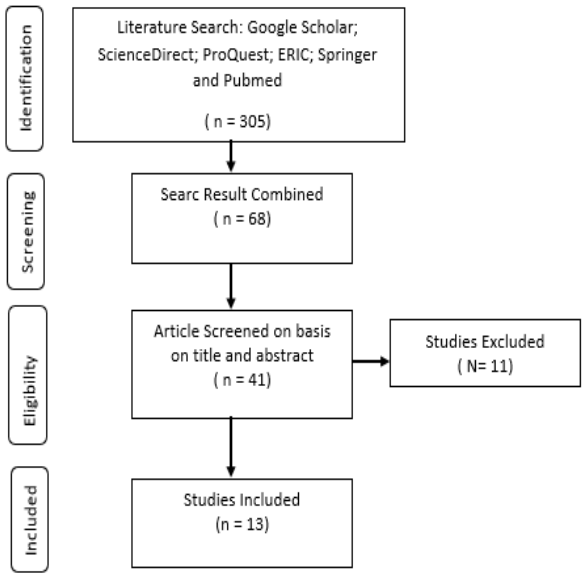

Figure 1. Data selection through preferred reporting items for systematic reviews and meta-analyses (PRISMA)

Data Analysis

Data analysis calculates effect size values, heterogeneity tests and analyzes publication bias with the help of JSAP applications (Borenstein & Rothstein, 2007). Furthermore, the criteria for effect size values are guided by the criteria (Cohen, 1988) which can be seen in Table 1.

Table 1. Effect Size Value Criteria (Cohen, 1988)

Effect Size	Criterion
0.20 ≤ 0.50	Low
0.50 ≤ 0.80	Medium
≥ 0.80	High

Furthermore, in calculating publication bias for meta-analysis research it is very important to predict effect size in general. Analysis of publication bias in this study with funnel plot and *Rosenthal Fail Safe N* (FSN) test.

Result and Discussion

Results

Based on the search of 305 studies accessed through the Google Scholar, ScienceDirect, ERIC, Springer and Pubmed databases related to online blended learning and critical thinking skills of biology students, 13 studies were obtained that have met the inclusion criteria. Research that has met the inclusion criteria is calculated the effect size value of each study analyzed based on the

journal code, year of publication, sample size, and jurna index. The results of the analysis of 13 studies can be seen in Table 2.

Table 2. Analysis of 13 Research Meets Inclusion Criteria

Journal Code	Year	N	ES	Effect Size Criteria
V1	2021	40	0.76	Medium
V2	2021	90	1.45	Hight
V3	2020	86	2.11	High
V4	2019	112	0.98	High
V5	2023	220	1.16	High
V6	2023	140	1.09	High
V7	2021	40	0.87	High
V8	2018	34	0.62	Medium
V9	2018	20	0.85	High
V10	2022	20	1.78	High
V11	2023	70	2.10	High
A12	2020	98	1.28	High
V13	2019	100	0.92	High

Based on Table 2, showing the analysis of 13 studies obtained effect size values ranging from (0.85 – 2.11) high effect size criteria and 0.62-076) medium effect size criteria. Furthermore, this meta-analysis research involved a sample size of 1070 students, 6 Scopus indexed studies, WOS indexed research studies and 7 SINTA indexed researches. The next step is to test the previous hypothesis to test the heterogeneity of the entire study. The results of the heterogeneity test can be seen in Table 3.

Table 3. Heterogeneity Test Results

	Q	Df	p
Omnibus test of Model Coefficients	82.922	1	< 0.001
Test of Residual Heterogeneity	458.095	12	< 0.001

Note. p value are approximate

Table 4. The Residual Heterogeneity Test Result

	Estimates	Lower bound	Upper Bound
τ^2	0.610	0.487	0.883
τ	0.589	0.312	0.791
I^2 (%)	94.023	91.972	96. 065
H^2	51.652	33.114	59.328

Based on Table 3 and 4 show as many as 13 effect sizes of heterogeneously distributed studies. This can be seen from the p value < 0.001; Q = 82.922; τ^2 or t > 0 and I2 (%) = 94.023 close to 100%. The next step is to calculate the summary effect value of the 13 research samples analyzed. The results of the summary effect size analysis can be seen in Table 5.

Table 5. Hajj test Summary Effect Size

	Estimates	Standard Error	z	p	Lower bound	Upper bound
Intercept	1.05	0.116	9.106	< 0.001	0.831	1,286

Based on Table 5 shows that value (Z = 9.106; p < 0.001). Next, the estimates standard error value is 0.1,05 [0.834; 1.416] high criteria. These results conclude that the online blended learning model effectively improves the critical thinking skills of biology students compared to conventional learning models

In addition, conduct a summary effect size analysis with the forest plot which can be seen in figure 2.

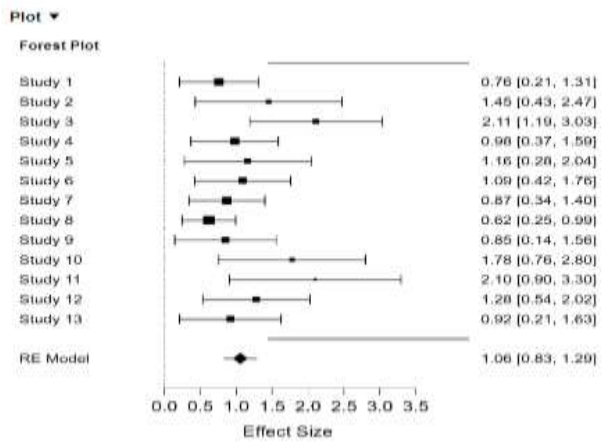

Figure 2. Forest plot effect size

Based on the figure 2 showing the overall effect size of the 13 studies analyzed had a significant effect. Next, analyze the publication bias of the 13 studies analyzed. In this meta-analysis research, publication bias can be identified using funnel plots. The results of the Funnel flot effect size analysis from 13 studies can be seen in figure 3.

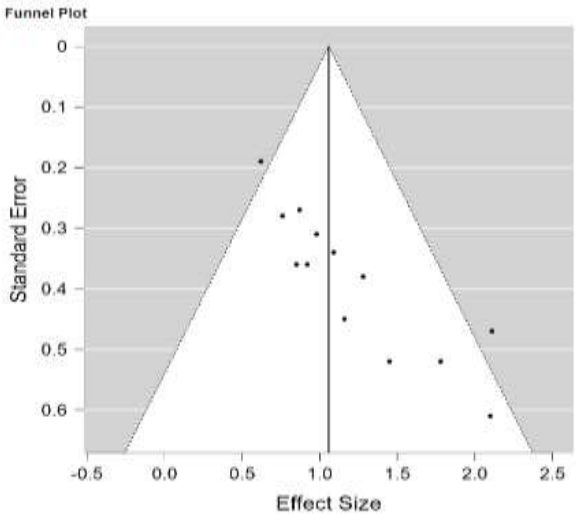

Figure 3. Funnel plot standard error

Based on figure 3, showing the results of effect size analysis with funnel plots cannot describe the analysis of curves whether symmetric or asymmetric. Therefore, it is necessary to do the Egger test. The results of the Egger test can be seen in Table 6.

Table 6. Egger Test Results

	z	p
Sei	1.251	1.420

Table 6 showing a p-value of > 0.05, the distribution of the funnel plot is symmetrical. The funnel plot showed no publication bias in this study. Furthermore, to increase the validity regarding publication bias, it is necessary to conduct a Fasil Safe N (FSN) test. The results of the safe N fail test can be seen in Table 7.

Table 7. Safe N File Test Results

	Fail safe N	Target Significance	Observed significance
Rosenthal	596.000	0.050	< 0.001

Based on table 7 the safe N (FSN) file value is 5.96. Next, the value of the safe N file is compared to the value of k = (5.13) + 10 = 75. Therefore, the value of safe file N 5 96 / 7 5 = 7.94 > 0.05, then the analysis of 13 studies conducted did not have publication bias.

Discussion

Of the 305 studies obtained from Google Scholar, ScienceDirect, Springer, Wiley and Pubmed related to online blended learning and critical thinking skills of biology students, only 13 studies met the inclusion criteria. From the analysis of the summary effect size, the entire study analyzed obtained the value of summary effect size (r_E = 1,058) high criteria. These results show that online blended elarning is effective in improving critical thinking skills in biology students compared to conventional models. Research (Orhan, 2023; Farizi et al., 2019) stated that the online blended learning model is effective in improving the critical thinking skills of biology students in Indonesia. Online blended learning helps students be more active and creative in learning student biology (Wahyuningtias et al., 2021; Rahman et al., 2023; Ernawati & Sari, 2022), so that it can stimulate students to think critically.

Online *blended* learning can be done online or face-to-face so as to create a more interesting learning atmosphere (Cao et al., 2021; Sri Dwiastuti et al., 2021), to encourage students' interest and thinking skills (Akyüz & Samsa, 2009). Online blended learning can develop students' digital literacy to solve a problem (Sulisworo et al., 2020; Phakakat & Sovajassatakul, 2020). Furthermore, *online blended learning* can foster self-reliance in learning biology (Bazelais et al., 2022). Biology learning is guided by students to have the ability to think critically to solve a problem that occurs in life (Mahanal et al., 2019; Bustami et al., 2018).

Furthermore, biology learning is also needed for students to be more active and creative in mastering technology. Online blended learning is one of the effective learning models applied in biology learning. Research from Hayati et al. (2020), Saputri et al. (2018), and Naimnule et al. (2018) in biology learning activities students must have metacognitive skills and critical thinking to make it easier to analyze a problem that occurs. In addition, the existence of online blended learning is one solution for teachers to stimulate the critical thinking skills of Indonesian biology students (Rahman et al., 2022; Gunawan et al., 2020). Rochmad et al. (2020), that the online blended learning model can improve students' higher thinking skills.

Conclusion

From this analysis research it can be concluded that the summary effect size value (ES = 01.058) criteria is high and the total sample (N = 1070) of students. These findings show that online blended learning is effective in encouraging critical thinking skills in biology students compared to conventional learning. Online blended learning is one of the effective models to stimulate critical thinking skills in biology students. Online blended learning can help students be more creative and innovative in utilizing technology.

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Author Contribution

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Conflicts of Interest

The authors declare no conflict of interest.

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