International Journal of Education and Literature (IJEL)
Amik Veteran Porwokerto
https://ijel.amikveteran.ac.id/index.php/ijel/index
E- ISSN : 2829-6249
P -ISSN : 2829-6656

The Effect Of Stem-Based E-Learning On Students' Higher Order Thinking Skills In Indonesia: A Meta-Analysis

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ARTICLEINFO

Article history:
Received 03 April 2023
Received in revised form 02 May 2023
Accepted 30 June 2023
Available online 28 July 2023

Keywords:
learning influence, Higher Order Thinking Skills (HOTS), critical thinking skills.

ABSTRACT

Many studies have described meta-analysis on the overall effect of e-learning influence in learning. However, there has been no meta-analysis of the overall effect of STEM-based e-learning on Higher Order Thinking Skills (HOTS). The purpose of this study investigates the effect of STEM-based e-learning on students' critical thinking skills in Indonesia. This type of research is a Systematic Literature Review (SL) and meta-analysis. Data sources came from 10 national and international journals published in 2018-2023. The process of searching for data sources through Google Scholar, Science Direct, Wiley, Eric, and Springer. Data analysis used the Hedge formula to calculate effect size with the help of the JSAP application. The findings show that the effect size value (ES = 0.793) is medium. This explains that STEM-based e-learning provides a very high positive impact and is effective in improving students' Higher Order Thinking Skills (HOTS). Furthermore, HOTS characteristics do not cause heterogeneity in the results of STEM-based e-learning research on students' Higher Order Thinking Skills. The findings suggest that educators should choose STEM-based e-learning as one of the learning models to improve students' Higher Order Thinking skills in Indonesia.

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INTRODUCTION

Higher Order Thinking Skills (HOTS) is a high-level thinking ability that must be possessed by students (Shanti et al., 2022; Wardani et al., 2020; Hamzah & Yusoff, 2021; Putranta et al., 2021). Higher Order Thinking Skills (HOTS) are important for students to think critically in solving a difficult problem (Tsaparlis, 2020; Syafryadin et al., 2022; Razak et al., 2021). Students who have high-level thinking skills find it easier to understand the concepts of the lesson (How et al., 2022; Tyas et al., 2020). According to Royan & Diniyah (2022) stated that Higher Order Thinking Skills are highly emphasized on students in the 2013 curriculum so that students are able to solve problems in life. Furthermore, students who have Higher Order Thinking Skills will be more creative and innovative in learning (Akatsuka, 2019; Suprapto et al., 2020; Saepuzaman et al., 2021).

The level of Higher Order Thinking Skills of students in Indonesia is still low (Azid et al., 2022). This can be seen from the results of the Program of International Students Assessment (PISA) in 2015 Hodiyanto (2018) Indonesia is ranked 62 out of 72 member countries. PISA in 2018 the level of science literacy of Indonesian students is still low, the average score of Indonesian students is only 396, ranked 70 out of 78 member countries. (Zulkifli et al., 2022; Takiddin et al., 2020; Supriyadi et al., 2023; Elfira et al., 2023;

Oktarina et al., 2021). The Higher Order Thinking Skills criteria set by PISA put more emphasis on the ability to think, analyze, solve problems and communicate that are guided by students' Higher Order Thinking Skills. (Kahar et al., 2021; Alsowat, 2016; Kareem, 2022; Yunita et al., 2020).

The low quality of Higher Order Thinking Skills in students is influenced by various factors. Rintayati et al., (2021) stated that the low level of Higher Order Thinking Skills is caused by the learning model used by teachers that has not led to students' higher order thinking skills. The teaching and learning process is still teacher-centered (Sofianora et al., 2023; Suharyat et al., 2022; Zulyusri et al., 2022; Rahman et al., 2023), so that students are less active in learning. In addition, the evaluation questions of the student teaching and learning process have not led to students' Higher Order Thinking Skills (Fitri et al., 2018).

E-leaning is a learning system that is carried out electronically through a learning platform via the internet network (Berestova et al., 2022; Bakarman & Almezeini, 2021). Aurora & Effendi (2019) stated that e-learning helps students' learning process more interesting and interactive without time limit (Suharyat et al., 2022; Santosa et al., 2021 ; Nuryatin et al., 2022; Lee et al., 2020). The e-learning process helps students in mastering technology (Caratiquit, 2022). Saleem et al., (2021) stated that e-learning helps foster interest and motivation in learning so that students are more active in learning. E-learning helps students' learning activities more effectively and practically because it is accessed through the internet (Krasodomska et al., 2021). Furthermore, Science Technology Engineering and Mathematics (STEM) based e-learning is one of the solutions to improve students' Higher Order Thinking Skills (HOTS).

STEM is a learning approach that combines science technology engineering and math in the learning process (Akoz et al., 2022; Suharyat et al., 2023; Rahman et al., 2023; Eroğlu, 2021). Fadlelmula (2022) STEM learning helps students be more creative and innovative in learning and students understand the lesson more easily. The STEM approach helps students to encourage their thinking skills (Friedensen et al., 2018). Research results Mujib et al., (2020) stated that STEM learning can improve students' multiple intelligence skills. In addition, research results Wijayanto et al.,(2015) stated that STEM learning trains students to solve a problem in learning.

Furthermore, previous research Yaniawati (2012) e-learning can train students' knowledge skills in learning. Research by Kusumantara et al., (2017) learning through e-learning effectively improves student learning outcomes. Research results Ibrahim et al., (2014) e-learning can help students in encouraging motivation and better student learning outcomes. Marín et al., (2018) e-learning explains that students are more active and motivated to learn so as to encourage their critical thinking skills. Not only that, the results of research by Nisa (2012) learning with e-learning methods has a significant effect on student learning outcomes. Based on this problem, this study aims to investigate the effect of STEM-based E-learning on students' Higher Order Thinking Skills in Indonesia.

RESEARCH METHOD

This research uses systematic literature review and meta-analysis. The use of systematic literature review and meta-analysis to look at relevant primary studies with a quantitative approach (Suparman et al., 2021). Menurut (Kim et al., 2017; Saraç, 2018; tehrani & Yamini, 2021) The steps for systematic literature review and meta-analysis are 1) Determine inclusion criteria; 2) Study search process; 3) data extraction; 4) study selection; and 5) data analysis.

RESULT AND ANALYSIS

Studies on the effect of STEM-based e-learning on Higher Order Thinking Skills are still general in nature. So, to see a more focused systematic literature review and meta-analysis. Inclusion criteria in research using the Population, Interventions, Comparator, Outcomes, and Study Design (PICOS).

Literature search process

The literature search process in the study through the Google Scholar, Wiley, ScienceDirect, ProQuest, Eric and Springer databases. The keywords used in the literature search were "E-learning" STEM-based Elearning "Higher order thinking skills". So databases and keys help facilitate the search for studies that match the inclusion criteria.

Study Selection

In this research, the selection of studies using the PRISMA method. The steps in the PRISMA method are 1) Identification of data; 2) screening; 3) determining eligibility; 4) included in the data source.

Statistical Analysis

In this systematic literature review and meta-analysis, the effect size value was calculated using the Hedge formula (Borenstein & Hedges, 2009). Effect size criteria can be seen in Table 1.

Table 1. Effect Size Criteria

Effect Size	Criteria
$-0.15 \leq ES \leq 0.15$	Ignored
$0.15 < ES \leq 0.40$	Small
$0.40 < ES \leq 0.75$	Medium
$0.75 < ES \leq 1.10$	Hight
$1.10 < ES \leq 1.45$	Very Hight
$1.45 > ES$	High Influence

Source: (Musna et al.,, 2021; Karim , 2023; Santosa, 2021; Oktarina et al., 2021)

Furthermore, every publication is never free from publication bias. So, to determine the publication bias contained in each study must be valid and this analysis is very important to do (bolotin & Marotto, 2018; Zeng et al., 2021). To determine publication bias in meta-analysis through funnel plot test, fill and trim test and Rosenthal Fail-Safe N Test (FSN) test. Furthermore, the FSN test results were obtained from the N formula, namely (5K-10) where k is the number of studies involved. It can be concluded that all studies are not prone to publication bias. The Fill and Trim test associated with the Funnel plot serves to determine the number of studies that cause publication bias and over-analysis of effect size.

Furthermore, meta-analysis of the effect size of each study, combined effect size, effect size of moderator variables and publication bias were calculated with the help of JSAP application.

RESULT AND DISCUSION

Result

From the results of searching data sources from the Googel Scholar, ScienceDirect, Wiley, ProQuest, and Eric databases, a total of 663 journals related to the effect of STEM-based e-learning on elementary, junior high, high school and university students were obtained. However, there are 12 journals that have met the inclusion criteria. The effect size value of each journal can be seen in Table 2.

Table 2. Overall Effect Size

No	Penulis	Tahun	Hedge's	Standart Error	Kriteria Effect Size
1	Riyanti,	2020	0.88	0.421	Hight
2	Gustria & Fauzi	2020	0.92	0.319	Hight
3	Sigit *et al.*,	2022	1.06	0.210	Very Hight
4	Mufida *et al.*,	2020	0.64	0.231	Medium
5	Hasibuan *et al.*,	2022	0.70	0.391	Medium
6	Noor *et al.*,	2017	0.60	0.210	Medium
7	Kusuma	2020	0.73	0.326	Medium
8	Makhmudah *et al.*,	2021	0.83	0.201	Hight
9	Sury *et al.*,	2020	0.95	0.170	Hight
10	Wiyono e*t al.*,	2022	0.62	0.258	Medium
Average Effect Size value			0.793		Medium

Table 2 shows that the average value of Effect Size (ES = 0.793) with high criteria. This explains that STEM-based e-learning has a significant effect on students' higher order thinking skills. The next stage, determining the effect size model by conducting a heterogeneity test. The results of the heterogeneity test can be seen in Table 3.

Table 3. Heterogeneity Test Results

Model	n	Hedge's g	Standard Error	95 % CL	Q	P	Description
Fixed	10	0.710	0.076	[0.516;0.817]	29.10	0.00	H1 is accepted
Random	10	0.780	0.380	[0.422; 1.710]			

Based on Table 3. Showing the value of the heterogeneity test (Q = 29.10; p = 0.00 <0.05), the effect size in the study is heterogeneously distributed. These results explain the meta-analysis model used in this study is a random effect model. The average effect size value is 0.837. This finding is analyzed based on Cohen's framework in (Table.1), then the STEM-based e-learning learning model has a positive impact on Higher Order Thinking Skills (HOTS) with high criteria. Furthermore, it calculates the publication bias by using the Funnel Plot method. Funnel Plot analysis can be seen in Figure 1.

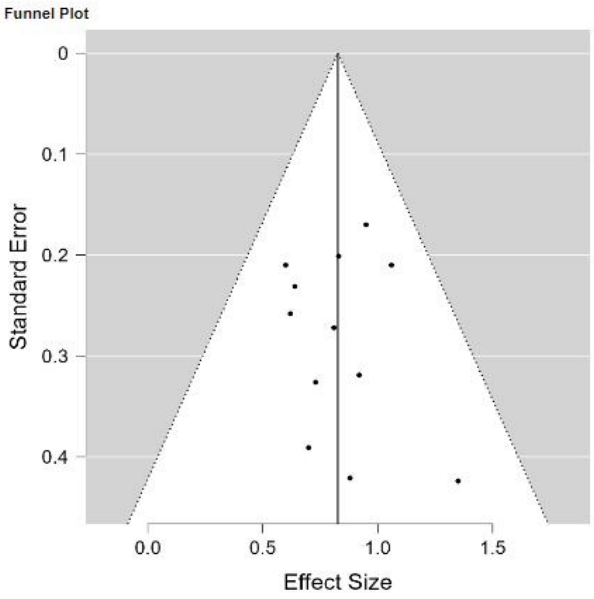

Figure 1. Funnel Flot of Hedge's Standard Error

Figure 1. Shows the results of analysis with the funnel plot method from 12 primary studies analyzed in the meta-analysis showing symmetrical effect size data, so it has a small publication bias. Next, conduct the Rosenthal Fail-Safe N (FSN) test to determine the possibility of publication bias. The results of the Rosenthal Fail-Safe N (FSN) test can be seen in Table 4.

Table 4. Rosenthal Fail-Safe N (FSN) test results

Classic Fail-Safe N	
Z-Value for observed studies	11.368
The P-value for observed studies	0.000
Alpha	0.050
Tails	2.000
Z for alpha	1.260
Number of observed studies	12
Number of missing studies that would bring p-value to > aplha	521.000

Based on Table 3. Shows that the Rosenthal Fail-Safe N (FSN) value is 521, then 521 (5.12 + 10) = 7.44 > 1 means that the research in the meta-analysis is resistant to publication bias. The next step is to calculate the p-value to test the hypothesis. This is to determine the overall effectiveness of STEM-based e-learning based on random effect models. The results of the overall analysis based on random effect models can be seen in Table 5.

Table 5. Overall analysis based on random effect models

Estimation Model	**n**	**Z**	**p**	**Effect size**	**Standart Error**	**95 % CL**
Randon effect model	10	5.011	0.000	0.827	0.271	[0.422; 1.710]]

Based on Table 5. The overall effect size value (ES = 0.793) with high criteria. Furthermore, the z value = 6.012 with p-value = 0.000 <0.5, meaning that the application of STEM-based e-learning is better for improving Higher Order Thinking Skills than conventional learning classes.

DISCUSSION

The application of STEM-based e-leaning has a positive impact on students' Higher Order Thinking Skills (HOTS) at school. This can be seen from the average Effect size value (ES = 0.837), meaning that STEM-based e-learning has a significant effect on Higher Order Thinking Skills (HOTS). Learning with STEM-based e-learning makes students' teaching and learning activities more interactive and fun (Berestova et al., 2022; El-aasar & Farghali , 2022). *E- STEM-based learning helps students utilize technology for teaching and learning* (Aljaser, 2019). Dewi *et al.,* (2020) stated that the teaching and learning process through STEM-based E-learning makes it easy for teachers and students to access information that can stimulate students' higher order thinking skills (HOTS).

Furthermore, STEM-based e-learning is effective in increasing the Higher Order Thinking Skill (HOTS) of students in Indonesia. It can be seen from the value (z = 6. 012 or p-value <0.00), then STEM-based E-learning is one of the solutions in improving students' HOTS. Nudin *et al.,* (2021) stated that E-learning is very effective for students and teachers to improve learning outcomes and students' Higher Order Thinking Skills (HOTS). Students who have high Higher Order Thinking Skills (HOTS) will find it easier to solve problems (Murthy, 2018; Bismala et al., 2022; Çalişir, 2022). So, STEM-based E-learning is very important to be implemented by teachers so that students can grow Higher Order Thinking Skills.

Baji *et al*., (2022) stated that students who learn through STEM-based E-Learning will be faster in obtaining information from various available on the internet. Students who have extensive knowledge will more quickly accept the subject matter delivered by the teacher (Ferdyan et al., 2021; Ferry et al., 2019; Friedensen et al., 2018). In this meta-analysis, E-learning has a high positive effect on students' thinking skills. Sari et al., (2021) E-learning has a huge influence in improving Higher Order Thinking Skills (HOTS) in Indonesia. Therefore, the application of STEM-based E-learning becomes a new learning in improving the progress of education in Indonesia. E-learning allows students and teachers to learn online through a learning platform (Hamad et al., 2022)

CONCLUSION

From this study it can be concluded that the effect size value (ES = 0.793) with a medium. This explains that STEM-based e-learning gives a very high positive impact and is effective to improve students' Higher Order Thinking Skill (HOTS). Furthermore, HOTS characteristics do not cause heterogeneity in the results of STEM-based e-learning research on students' Higher Order Thinking Skill. These findings suggest that educators should choose STEM-based e-learning as one of the learning models to improve students' Higher Order Thinking Skill in Indonesia. STEM-based e-learning helps students to grow their digital literacy in learning. Furthermore, learning through E-learning can be done online so that it helps students to be more nuanced in accessing learning resources.

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