



Meta-Analysis: The Effect of E-Learning-Based Mind Mapping on Students' Critical Thinking Skills

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Abstrak

Penelitian ini bertujuan untuk mengetahui efek size mind mapping berbasis e-learning terhadap kemampuan berpikir kritis siswa. Jenis penelitian adalah penelitian meta-analisis. Sumber data dalam penelitian meta-analisis ini adalah 11 jurnal nasional dan internasional yang telah terbit dari tahun 2018-2023. Metode penyeleksian sumber data adalah metode PRISMA. Proses penelusuran sumber data melalui Google Scholar, Eric dan Proquest. Teknik pengumpulan sumber data adalah observasi langsung dan dokumentasi melalui database jurnal. Analisis data adalah analisis kuantitatif dengan menghitung nilai effect size, standart error dan nilai rata-rata (mean) dengan bantuan aplikasi JSAP. Hasil penelitian ini menunjukkan bahwa bahwa nila rata-rata effect size sebesar = 0.812 dengan kriteria tinggi. Temuan ini menjelaskan model mind mapping berbasis e-learning berpengaruh signifikan terhadap kemampuan berpikir kritis siswa. Model mind mapping berbasis e-learning menumbuhkan kemampuan berpikir kritis sehingga mendukung literasi digital siswa dalam belajar

Kata Kunci: *Mind Mapping, E-Learning, Pendidikan, Berpikir Kritis, Meta-analisis*

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Abstract

This study aims to determine the effect of e-learning-based mind mapping on students' critical thinking skills. The type of research is meta-analysis research. The data sources in this meta-analysis research are 11 national and international journals that have been published from 2018-2023. The method of selecting data sources is the PRISMA method. The process of searching for data sources through Google Scholar, Eric and Proquest. The technique of collecting data sources is direct observation and documentation through the journal database. Data analysis is quantitative analysis by calculating the effect size value, standard error and average value (mean) with the help of the JSAP application. The results of this

study indicate that the average effect size value is = 0.812 with high criteria. This finding explains that the e-learning-based mind mapping model has a significant effect on students' critical thinking skills. The e-learning-based mind mapping model fosters critical thinking skills so that it supports students' digital literacy in learning.

Keyword: *Mind Mapping, E-Learning, Education, Critical Thinking, Meta-analysis*

Introduction

Critical thinking is a skill that students need in facing the industrial revolution 4.0 towards 5.0 society (Nurtamam et al., 2023; Elfira et al., 2023; Zulyusri et al., 2023; Yustiana et al., 2022). Temel (2022) Critical thinking is an ability that a person has to analyze a problem systematically and logically. Critical thinking is very important for students in solving a problem in learning (Chusni et al., 2020; Nur et al., 2023). Furthermore, critical thinking skills encourage students to understand the lesson content more easily (Amin et al., 2020; Arisoy & Aybek, 2021). Critical thinking skills play an important role in solving a phenomenon in everyday life (Ayuningrum et al., 2015).

Indonesian students' thinking skills in the era of the industrial revolution 4.0 are still in the low category (Rahman et al., 2023; Zulkifli et al., 2022; Suryono et al., 2023). The low critical thinking skills of students are influenced by the teacher-centered learning process, less supportive facilities and learning models that are not appropriate (Londa & Domu, 2020; Warsah et al., 2021; Wayan Santyasa et al., 2021). In addition, the learning process tends to be passive, making it difficult for students to understand the subject matter (Astika et al., 2013; Suharyat et al., 2022). Furthermore, the results of the 2018 PISA survey of Indonesian students' critical thinking skills in science literacy obtained a score of 396, ranked 71 out of 78 members (Rahman, et al., 2023; Putra et al., 2023). This is supported by the TIMSS results which show that Indonesian students'

critical thinking skills are ranked 45 out of 50 countries (Nurlaeli et al., 2018; Jamaludin et al., 2022). So, students' thinking skills in learning must be improved through the selection of the right learning model.

Mind mapping is a learning model that requires students to be able to map a concept of information in accordance with their mind map (Marxy, 2017; Hakim et al., 2019; Sezer, 2022; Akanbi et al., 2021). The mind mapping model can improve student learning outcomes and reading skills (Rahmatika et al., 2019; Sari et al., 2016). Gündüzalp (2023) The mind mapping learning model can improve students' meta-cognitive abilities. Furthermore, the mind mapping model can train students to develop science process skills in learning (Polat et al., 2017; Supriyadi et al., 2023; Alhajaji et al., 2020). The mind mapping learning model is able to help students more quickly remember the subject matter so as to foster student motivation in learning (Setya et al., 2016; Jones et al., 2012).

E-learning is a process of learning activities conducted online through a learning platform (Santosa et al., 2021; Priadi et al., 2021). Research results by Yaniawati (2012) states E-learning helps students learn independently and creatively. Therefore, the e-learning-based mind mapping learning model encourages students to think actively so as to stimulate their critical thinking skills in learning (Kurti et al., 2022; Leontyeva, 2021). Research results Yıldızlı et al., (2020) stated that the e-learning-based mind mapping learning model can grow students' interest and

motivation in learning. In addition, the e-learning-based mind mapping learning model increases student activity in learning so as to stimulate students to think critically.

Previous research by Avdagic et al., (2021) mind mapping learning model improves students' meta-cognitive skills in learning. Research results Alderbashi & Moussa (2022) mind mapping learning can encourage students' reading interest in getting information. However, in reality, there are many studies on mind mapping learning models but still few describe the size effect of e-learning-based mind mapping learning models in education. Based on these problems, this study aims to determine the size effect of e-learning-based mind mapping on students' critical thinking skills.

Methods

This type of research is meta-analysis research. Meta-analysis is research that analyzes previous studies that can be statistically analyzed (Oktarina et al., 2021; Razak et al., 2021; Suparman et al., 2021; Ichsan et al., 2023; Supriyadi et al., 2023). The data sources in this meta-analysis came from 11 national and international journals published from 2018-2023. The method of selecting data sources is the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method which can be seen in Figure 1. Search for data sources through Google scholar, Eric and ProQuest.

Furthermore, the inclusion criteria in this study are 1) data sourced from international and national journals indexed by SINTA and Scopus; 2) experimental or quasi-experimental type of research; 3) data related to mind mapping mode and students' critical thinking skills and 4) research data has complete data to calculate effect size. Data collection

techniques are direct observation and documentation. Data analysis in the research is statistical analysis by calculating the effect size value of each study, conducting heterogeneity tests and selecting estimation models, calculating publication bias and testing research hypotheses with the help of JSAP. The effect size criteria in this study can be seen in Table 1.

Table 1. Effect Size Criteria

Effect Size	Kriteria
$0.00 \leq ES \leq 0.20$	Ignored
$0.20 \leq ES \leq 0.50$	Low
$0.50 \leq ES \leq 0.80$	Medium
$0.80 \leq ES \leq 1.30$	High
$130 \geq ES$	Very High

Sumber: (Aisyah & Usdiyana, 2022; Sofianora et al., 2023; Rahman et al., 2023)

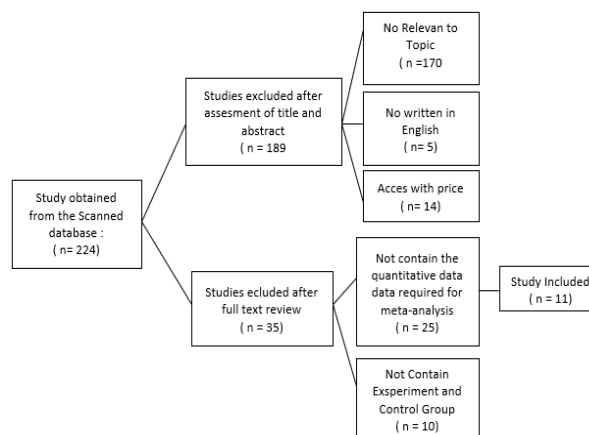


Figure 1. Data Source Selection Process with PRISMA Method

Result and Discussion

From the analysis of 224 national and international journals related to the e-learning-based mind mapping learning model on critical thinking skills, only 11 journals met the inclusion criteria. Journals that meet the inclusion criteria are used as data sources in the meta-analysis. Furthermore, the data sources in this meta-analysis were calculated the effect

size (ES) and Standard Error (SE) values which can be seen in Table 2.

Tabel 2. Effect Size and Standard Error of Each Data Source

Kode Jurnal	Year	Ukuran Sampel	Effect Size	Standard Error (SE)	Kriteria Effect Size
R1	2018	30	0.75	0.33	Medium
R2	2021	22	0.91	0.41	High
R3	2020	50	1.25	0.69	High
R4	2020	26	0.88	0.40	High
R5	2019	36	0.66	0.31	Medium
R6	2019	30	0.83	0.49	High
R7	2023	30	0.41	0.30	Low
R8	2023	24	0.96	0.52	High
R9	2021	20	1.05	0.64	High
R10	2019	48	0.52	0.28	Medium
R11	2023	14	0.72	0.38	Medium
Average effect size			0.812		High

Based on Table 2. Explains the average effect size value of 0.812 high criteria. These results explain the E-learning-based mind mapping model has a positive influence on students' critical thinking skills. Furthermore, knowing the meta-analysis model used in this study, a heterogeneity test was conducted. The results of the heterogeneity test can be seen in Table. 3

Table 3. Heterogeneity Test Results based on Effect Model

			Null Hypothesis Test (2-tail)		Heterogeneity			
Model	n	Hedges' g	95% CI	Z-value	P-value	Q-value	df(Q)	P-value
Fixed	11	0.76	[0.571; 0.686]	14.0	0.0	177.0	10	0.00
Random	11	0.87	[0.547; 0.789]	7.17	0.0			

Based on Table 4. It shows that the effect size provides a significant difference. Furthermore, the p-value <0.05 heterogeneity analysis shows that the random effect model is better than the fixed effect model. Furthermore, calculating publication bias using funnel plot can be seen in Figure 1.

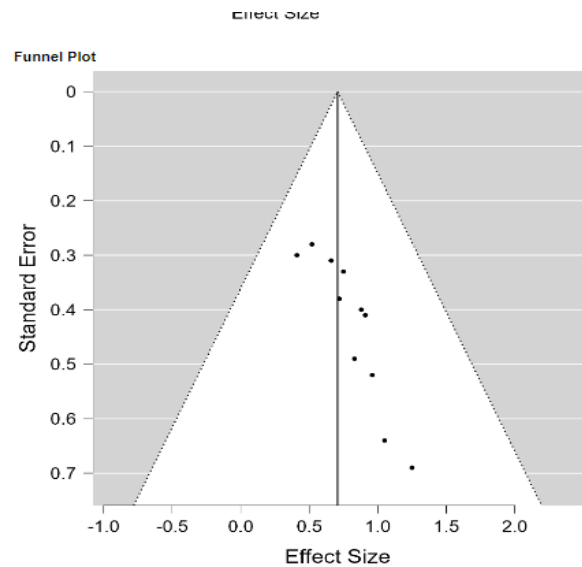


Figure 2. Funnel Plot

Figure 2 shows that the effect size is not entirely symmetrical on the vertical line. Therefore, it is necessary to conduct the Fail Save N (FSN) test to see the publication bias in this study. The Fail Save N test results can be seen in Table 4.

Table 4. Fail Save N (FSN) Test Results

Classic Fail Safe N	
Z-value for observed studies	6.125
Th P-value for observed studies	0.000
Alpha	0.050
Tail	2.000
Z for Alpha	1.780
Number of Observed Studies	11.00
Number of missing studies that would p-value t0 > alpha	151.000

Based on Table 4. The value of the Fail Safe N (FSN) test results is 151, then entered in the formula $151 / (5.11 + 10) = 2.32 > 1$, meaning that each study used is resistant to publication bias. The next step is to calculate the p value of the study to conduct hypothesis testing. This aims to see the effectiveness of the overall e-learning-based mind mapping model using random effect size. The results of hypothesis testing can be seen in Table 5.

Table 5. Hypothesis test results based on Random Effect Size

model	n	Z	p	Effect Size	Standard Error	95% CI
Random effect model	1	6.12	0.0	0.87	0.172	[0.547;0.789]
	1	5	0	2		

Based on Table 5. The effect size value of the whole study is 0.872 with a Z value of 6.125 or $p < 0.05$, meaning that the e-learning-based mind mapping learning model is effective in improving critical thinking skills than the conventional learning model.

Discussion

The application of the e-learning-based mind mapping model has a significant effect on students' critical thinking skills in learning. This can be seen from the average effect size value of 0.812 with high criteria. The results of this study are in line with (Nurtanto et al., 2020) e-learning-based mind mapping learning model affects students' cognitive skills in learning activities. Research results (Nasution et al., 2019) The e-learning-based mind mapping model has a positive effect on learning outcomes and critical thinking skills in students. The e-learning-based mind mapping learning model encourages students to be more independent and creative in learning (Gündüzalp, 2023; Al-swalha, 2021; Ritchie et al., 2013). In addition, the e-learning-based mind mapping model fosters student motivation and interest in learning so as to encourage critical thinking skills in students (Ristanto et al., 2022; Rahman et al., 2023; Prabha, 2020).

Learning activities based on e-learning can create a more interesting learning atmosphere (Bakarman & Almezeini, 2021). E-learning based Mind mapping model can be accessed by students and teachers through the internet

network so as to create learning without time limit (Kumaran, 2015; Santosa et al., 2021; Omwenga & Hudollu, 2018). Thus, critical thinking skills play an important role in mastering educational technology (Chua 2021). Furthermore, research results (Gültepe & Kılıç, 2021) Thinking skills help students more easily solve all the problems that occur in their learning activities. Therefore, the e-learning-based mind mapping model is one solution to improve students' creative thinking skills.

Furthermore, the e-learning-based mind mapping model effectively improves students' critical thinking skills. This can be seen from the value ($Z = 6.125$) or $p < 0.05$. This result is in line with (Permana et al., 2019; Sihombing et al., 2018) stated that the application of e-learning-based mind mapping model is effective to improve students' critical thinking and metacognitive skills in the learning process. The e-learning-based mind mapping model trains students to be creative in obtaining learning information so that it can encourage critical thinking skills (Herliandry et al., 2019; Diani et al., 2019). Research results (Maksum, 2021) m stated that critical thinking skills train students more easily in understanding the material and can analyze problems that occur in life. Furthermore, critical skills are important things that students must improve in facing the 21st century (Jamaludin et al., 202; Erdogan, 2020; Fradila et al., 2021; Ilkorucu et al., 2022). Therefore, the e-learning-based mind mapping learning model is more effective to be implemented in schools so as to help teachers train students' critical thinking skills.

Conclusion

Based on this research, it can be concluded that the average effect size value is = 0.812 with high criteria. This finding explains that the e-learning-based

mind mapping model has a significant effect on students' critical thinking skills. The e-learning-based mind mapping model fosters critical thinking skills so that it supports students' digital literacy in learning. The e-learning-based mind mapping learning model is more effective to improve students' critical thinking skills than the conventional learning model. This model helps students and teachers to be more independent and creative in implementing learning activities.

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