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Is Blended Learning Effective in Developing Critical Thinking Skills? : A Meta-Analysis Study

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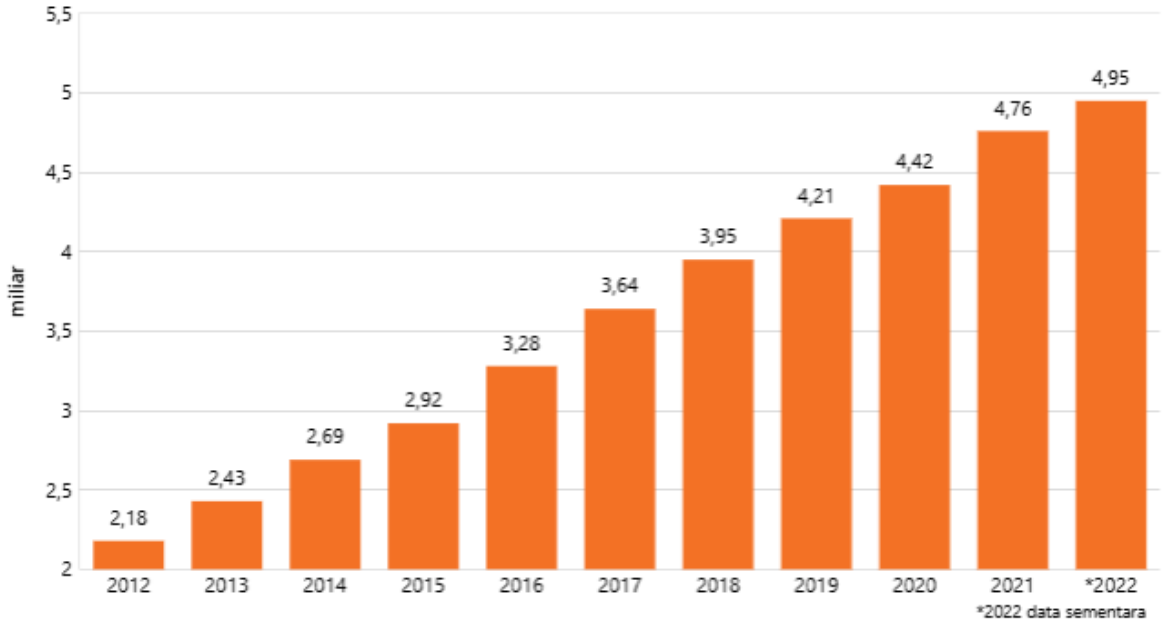
Abstract
Increasingly sophisticated and modern technology provides convenience to humans in various fields. Many benefits can be received, although there is still a side to the problem regarding technological developments. This also happens in the field of Education which has utilized technology today. Blended learning with a blended method is an innovation in Education that is associated with the critical thinking ability of school students at the primary, secondary and higher education levels. This research is quantitative with a meta-analysis design using 24 article studies with predetermined criteria with secondary data sources sourced from Google Scholar, Research Gate and Science Direct with the years 2014, 2018, 2019, 2020, 2021 and 2022. The article is determined using mean aggregates. The existence of coding, according to the purpose, of this article focused on N, M, and SD data. The data processing is assisted by Microsoft Excel and JASP software. This is done to estimate aggregates, project forest plots, test heterogeneity, and investigate publication bias. The analysis found that there is accuracy in using a random effect model aggregate with a high heterogeneity effect size and no problems in publication, so following the research objective the blended learning model is effective in developing critical thinking skills in learning so that technology in education has a positive impact.

Keywords: Blended Learning, Critical Thinking, Meta-Analysis, Effective

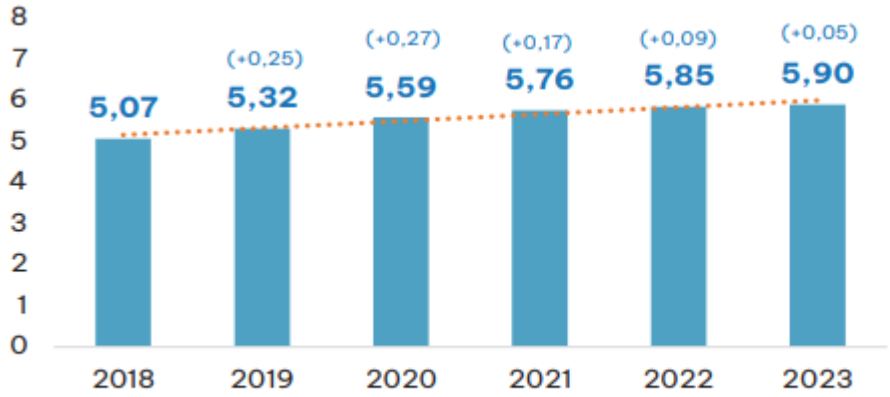
INTRODUCTION

The current era of technological development is so fast that humans must always be able to adapt to the situation. Technology was created by providing benefits to humans to make it easier to carry out their activities. Technology is a design or design for action tools that reduce uncertainty in causal relationships in achieving a desired result. Technology usually has two aspects, namely hardware and software (Rusman, et.al, 2013). Currently, the flow has changed for the better due to the development of the internet and the telecommunications subsector with speed, speed, and massive implementation and deployment of technology in the service delivery system. (Murphy et al., 2014; Ikpe et al., 2017). This technological development affects fluctuations in the number of internet users in the world. As seen in Figure 1. That is the number of world internet users which tends to increase every year from 2012-2022.

Figure 1. Number of Internet Users in the World (2012 - 2022)



The increase in internet users due to technological advances is also happening in Indonesia, especially information and communication technology (ICT). ICT has not only changed the way we communicate but also the way we work, learn and interact. Increasingly sophisticated digital infrastructure enables faster and more efficient access to information, increases productivity, and facilitates previously unimaginable innovations. ICT development also encourages better system integration, which in turn supports a wide range of industries, from health to education, as well as the public and private sectors. BPS compiles an index that describes Indonesia's ICT development under the name ICT Development Index. This index has a scale of 0-10 where the higher the index value indicates better ICT development in a region. Conversely, the lower the index value indicates less optimal ICT development in a region. This ICT Development Index refers to the methodology published by the International Telecommunication Union (ITU) in 2016.



Development of Indonesia's ICT Development Index, 2018-2023 (BPS, 2024)

Changes due to technology in society hit various fields as well as the field of education. Education is a process of individual change in knowing and understanding from what is not yet known and not yet understood which is certainly characterized by a change in behavior. Education as a vehicle for acculturation must be able to produce cultured and civilized humans who can develop intelligence of thought (olah pikir),

sensitivity of taste (olah rasa), creativity of spirit (olah karsa), and agility of body (olah raga) (Latif, 2020). What is the purpose of education? To teach the culture and values of society to the younger generation? To prepare people to enter the workforce? To teach children about the culture of the society they live in? To reproduce the class system and teach people about their place in life? To give jobs to many people who are not skilled to do anything other than teach? To keep children off the streets until they are old enough to work? To create a well-trained workforce? (Osborne & van Loon, 2005). National education functions to develop abilities and shape the character and civilization of a dignified nation in order to educate the nation's life, aims to develop the potential of students to become human beings who are faithful and devoted to God Almighty, noble, healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens. (Law of the Republic of Indonesia No. 20 Year 2003).

The technology used provides convenience in the aspects of teaching and education so that it plays an important role in achieving educational goals. Innovation, which is the nature of technology, certainly varies in types and methods so that with the blended learning system or can be said to be a mixed system in learning. This use provides a new color in learning that involves internet network technology. Blended learning consists of the words blended and learning. Another term that is often used is hybrid course (hybrid = mixture/combination, course = course/subject). So blended learning refers to learning that combines or blends face-to-face learning and computer-based learning (online and offline) (Munir, 2017). Blended learning is one of the alternative learning strategies that can be used by teachers in the current era of globalization (Aslam, 2015; Anggraeni, 2019). Learning with modern technology becomes teachers and students have a very wide range of learning resources. Blended learning is currently one of the options. Blended learning approaches have the potential to provide cost savings for learners and educational institutions when compared to conventional classroom learning while maintaining face-to-face meetings (Graham, 2006; Elgohary, et.al., 2022). Blended learning can facilitate optimal learning by providing various learning media to attract students' attention and develop their knowledge. In blended learning, teachers act as facilitators and media in the learning process. Teachers provide instructions or learning materials and provide guidance to students in carrying out learning activities and utilize the technology used in learning used in learning. (Prahmana, et. al, 2021).

Blended Learning is one of the innovative learning models in the 21st century, of course, aiming to get maximum results from both cognitive, affective, and psychomotor aspects. Related to education in the 21st century, one of the competencies that must be possessed by students is critical thinking. The concept of learning in the 21st century uses the 4Cs, namely: Critical Thinking and Problem Solving, Creativity and Innovation, Collaboration, and Communication (cerdasberkarakterterterter.kemdikbud.go.id). John Dewey stated that critical thinking is basically an active process, where a person thinks about something deeply, asks questions, and finds relevant information rather than passively waiting for information (Fisher, 2009; Kemendikbud, 2018). Critical thinking is based on Ki Hadjar Dewantara's concept (understand, feel, and act). First, critical thinking must be based on understanding, understanding is understanding or knowing about something, second, the point of feeling must be manifested in the practice of recitation. Third, “nglakoni” (doing) is the last stage of understanding and feeling. Critical thinking will not become an empirical practice without being manifested in real life. Critical thinking without the previous two "stance" points will also lead to a superficial attitude. Indeed, the dimension of doing is often overlooked in memorization practices. Therefore, habituation is needed, which according to the concept of behaviorism is achieved through repeated activities, so that in the end it becomes a habit (Pratama, 2020). Critical thinking must be possessed by students to become qualified individuals in order to adapt to the current era full of technological and knowledge innovations. This can be developed in the learning process at school with an innovative learning model, namely blended learning. Various models can be used but the choice

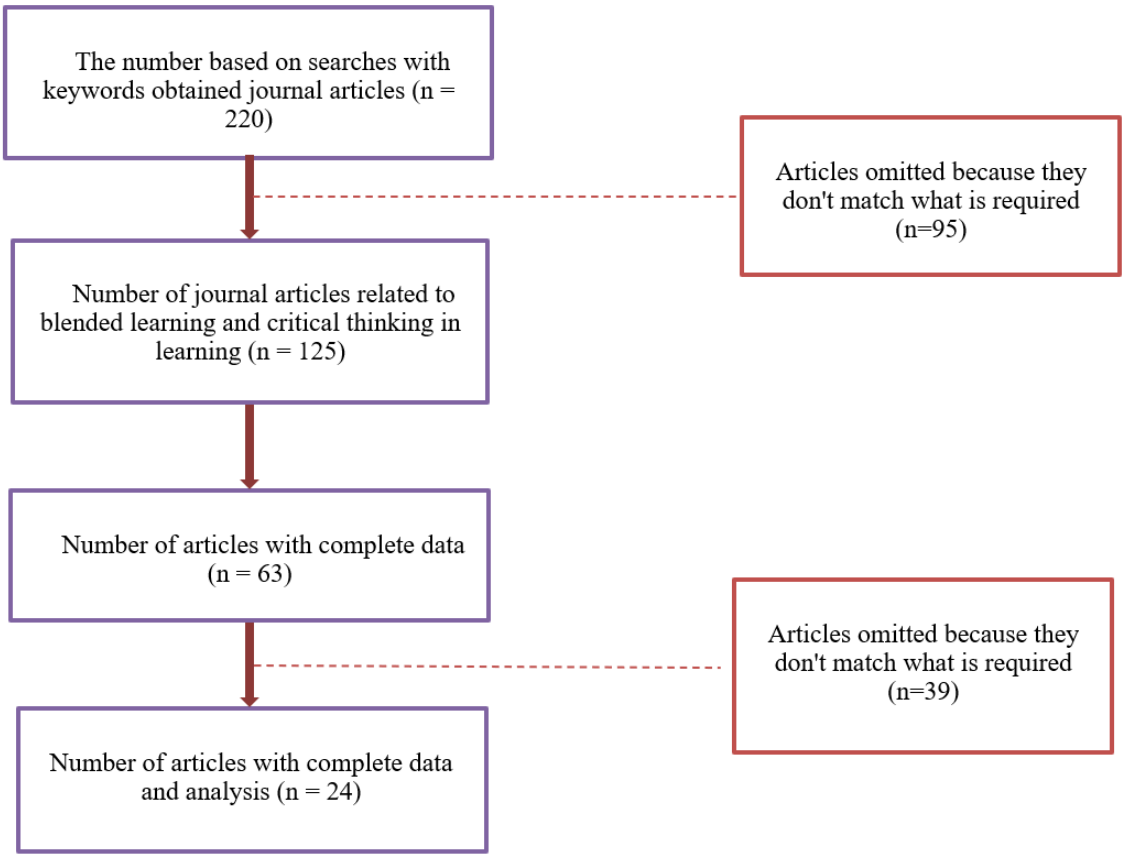
that is relevant to technology is blended learning. Therefore, it is important to know the effectiveness of critical thinking skills through the blended learning model applied.

METHODS

The method used in this study is quantitative with meta-analysis design. The use of me-ta-analysis by knowing the effectiveness of critical thinking skills through a blended learning model. The meta-analysis approach is research using existing studies that other researchers have used carried out systematically and quantitatively to obtain accurate conclusions (Retnawati, et.al., 2018). The category of meta-analysis techniques is a secondary analysis technique because this technique focuses on synthesizing the results of primary analysis. (Hedges & Olkin, 1985; Soetjipto; 1995). This study used the average effect size by choosing the type of quasi-experimental research, Classroom Action Research (PTK), Correlational, R n D (Research and Development). The results of the data taken are post-test data after applying blended learning to learning.

The variables in this study are blended learning and critical thinking, namely in seeing the effectiveness of the model on the development of students' critical thinking skills. Determi-nation of criteria in research related to blended learning variables and critical thinking skills, namely 1). Inclusion criteria include the language used Indonesian and English, Respondents who are subjected to treatment from the article are elementary, high school, vocational and uni-versity students with sample variations specified in each article, Treatment is students who expe-rience a blended learning model in certain subjects, The comparison used is blended learning by combining face-to-face learning and online learning by maximizing media digital, The research results needed with average aggregate are N (number of samples), M (Mean), and SD (Standard Deviation). 2). Exclusion criteria include: Languages used other than Indonesian and English, Respondents are all students from early, primary, secondary, and higher education levels, Treat-ment is students who do not experience a blended learning model but only with a face-to-face or full online model, The comparison used is learning that is not blended learning so that it can be face-to-face learning or full online, The results of the study that there is no mean or incomplete aggregate for N (number of samples), M (Mean) and SD (Standard Deviation) in one article. Af-ter determining the inclusion and exclusion criteria, the article search is carried out using several keywords, namely "blended learning and critical thinking", "blended learning in education", "blended learning and critical thinking", "blended learning and critical thinking in schools", "blended learning towards critical thinking". The articles obtained are sourced from Google Scholar, Science Direct, and ResearchGate, then downloaded and selected according to prede-termined criteria. Search and data extraction was carried out after obtaining articles from three sources totaling 225 articles then articles related to blended learning and critical thinking in learning a total of 180 articles were then reselected according to the completeness of data with post-test results available N, M, and SD there were 63, after that it was re-selected with com-pleteness of data and feasibility of articles totaling 24 articles. The following is a picture of the chart for determining the selected article:

Figure 3. Sampling Chart Diagram



Determination of samples obtained by 24 articles that followed the criteria and then car-ried out a coding process by the research objectives consisting of the author's name, article title, year, type of research, level of education, N, M, SD, which was then carried out data analysis. In this case, using Microsoft Excel in coding and JASP software in analyzing to get data processing results that are following research objectives.

RESULTS

Based on the results of research that has been done, 24 articles were obtained with variables of blended learning and critical thinking. The articles are grouped by category as fol-lows:

Table 1. Article Description

Article Criteria	Article Grouping	Number of Articles	%
Year of Publication	2014	1	4
	2018	2	8
	2019	3	13
	2020	7	29
	2021	6	25
	2022	5	21
Education Level	SD	5	21

	SMA	9	38
	SMK	1	4
	Perguruan tinggi	9	38
Model Type	Blended learning	24	100
Related variables	Berpikir Kritis	24	100
Research location	Malang	1	4
	Banjarmasin	1	4
	Mojokerto	1	4
	Tasikmalaya	1	4
	Medan	2	8
	Lampung	2	8
	Banten	1	4
	Biereun	1	4
	Serang	2	8
	Kuningan	1	4
	Thailand	1	4
	NTB	1	4
	Purworejo	1	4
	Boyolali	1	4
	Makasar	2	8
	Pati	1	4
	Cimahi	1	4
	Surabaya	1	4
	Indramayu	1	4
	Rejang lebong	1	4

Based on the table above, it can be explained that the articles obtained by several 24 have research locations in the territory of Indonesia with the distribution of cities as in the ta-ble with almost the same number for each location, namely 1 and at most are the same 2 loca-tions and there is 1 research location outside Indonesia, namely Thailand. Regarding the pub-lication year of publication articles, in 2020 there were 7 articles, the second was in 2021 with 6 articles, and in 2022 5 articles. Related to the oldest article in 2014 there was only 1 article chosen because the data presented was appropriate as the purpose of the study. Respondents who experienced learning with a blended learning model consisted of elementary, high school, vocational, and tertiary levels. High schools and colleges have the same number of 9 articles selecting students with that level of education. The entire article examines blended learning as a learning model and critical thinking for related variables so that the description data is under the research objectives.

Meta-analysis Data Tabulation

Articles that have been described according to the established inclusion criteria are compiled in the average aggregate selected in this study to see the SE and ES values in addition to the known N number of samples, M as the Mean, and SD standard deviation. The following is a table of presentation of calculation results:

Table 2. Data Tabulation Random Effect Models

No	Artikel	N	M	S	Min	Max	SE	ES	W	w.ES
1	Anggian Anggraeni, dkk	34	69.76	11.481	0	100	1.968975	69.76	0.25794	17.99393
2	Eko Susilowati, dkk	25	80.67	3.78	0	100	0.756	80.67	1.749671	141.146
3	Ika Wahyunita,dkk	30	29.933	8.379	0	100	1.529789	29.933	0.427304	12.79049
4	Dani ramdani, dkk	34	71	7.475	0	100	1.281952	71	0.608494	43.2031
5	Winando Marito & Nova Riani	25	76.125	7.37747	0	100	1.475494	76.125	0.45933	34.96652
6	Wayan Suana, dkk	32	96.34	5.7	0	100	1.007627	96.34	0.984918	94.88704
7	Alim Parangin-Angin,dkk	25	86.07	6.53	0	100	1.306	86.07	0.586292	50.46212
8	Dewi Anggraeni	70	68.48	13.04	0	100	1.558578	68.48	0.411664	28.19075
9	Zulhamdi, dkk	51	90.33	8.65	0	100	1.211242	90.33	0.681613	61.57012
10	Yus Ramadgenny, dkk	31	16.61	3.612	0	100	0.648734	16.61	2.376108	39.46716
11	Yeyen Suryani, dkk	23	53.91	14.23	0	100	2.96716	53.91	0.113584	6.123326
12	Muncarno, Nally Astuti	18	71.57	15.35	0	100	3.61803	71.57	0.076393	5.467474
13	Panita Wannapiroon, Ph.D.	28	43.2	54	0	100	10.20504	43.2	0.009602	0.414815
14	Arif Rahmat Zain & Jumadi	35	77	7	0	100	1.183216	77	0.714286	55
15	Prasetyo Budi Darmonoa&Isnaeni Maryam	25	72.76	92.19	0	100	18.438	72.76	0.002942	0.214025
16	Bowo Sri Mulyanto, dkk	36	52.1	9.4	0	100	1.566667	52.1	0.407424	21.2268
17	Della Fadhilatunnisa, dkk	35	72.74	6.363	0	100	1.075543	72.74	0.864459	62.88072
18	Prihadi, Murtono and Gunawan Setiadi	30	84.59	6.915	0	100	1.2625	84.59	0.627389	53.07083
19	Hasanah hasanah&Muh.Nasir Malik	47	81.4	7.282	0	100	1.062189	81.4	0.886332	72.14744
20	Mila Amalia and Sapriya	40	77.55	42.59	0	100	6.73407	775.5	0.022052	17.1012
21	Yus Rama Denny, dkk	31	16.61	3.612	0	100	0.648734	16.61	2.376108	39.46716
22	Lilik Channa	25	90.32	6.799	0	100	1.3598	90.32	0.540816	48.84655
23	Mellawaty&Mochammad Taufan	19	78.1053	9.38021	0	100	2.151968	78.1053	0.215938	16.86588
24	Marta Triyanti	71	46.94	9.81	0	100	1.164233	46.94	0.737769	34.63087

Heterogeneity Effects Size

Heterogeneity is used to see the diversity of characteristics of the group, namely in articles that have been set. This diversity is a difference that can be caused by the existing effect size. The following is a table of fix and random effects:

Table 3. Fix and random Effects

Fixed and Random Effects

	Q	df	p
Omnibus test of Model Coefficients	217.258	1	< .001
Test of Residual Heterogeneity	14489.360	23	< .001

Note. *p* -values are approximate.
Note. The model was estimated using Maximum Likelihood method.

Based on the table, it can be explained that the heterogeneity of Q is to test the heterogeneity of effect size. The heterogeneity Q of the data is shown by the number 217.258 with p-value <0.001 it can be interpreted that there is high heterogeneity in the effects size of the data owned so that it is following using the random effects model. For effects size. The following table is about residual heterogeneity estimates from data processing:

Table 4. Residual Heterogeneities Estimates

Residual Heterogeneity Estimates

	Estimate
τ^2	477.552
τ	21.853
I^2 (%)	99.677
H^2	309.534

The table explains that the figure 99,677 for I^2 (%) means that heterogeneity is large so it il-lustrates the population difference due to >50%. The summary effects (coefficients) of the da-ta are as follows:

Table 5. Summary Effects (Coefficients)

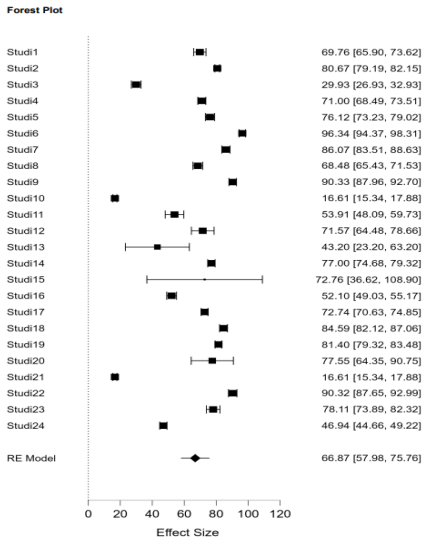
Coefficients

	Estimate	Standard Error	z	p
intercept	66.868	4.537	14.740	< .001

Note. Wald test.

The table above describes the Summary effect (Coefficients) of 24 research articles on the effectiveness of blended learning in improving critical thinking skills. The table shows a summary effect (estimate) of 66,868 with a standard error of 4,537 and a z-value of 14,740. The value in the estimate is positive so it is positively related. This means that the value of z = 14.740 and p <0.05 then the blended learning model can improve critical thinking skills in students. After looking at the heterogeneity of effects size study data, here is a picture of the forest plot:

Figure 4. Forest Plot Studi



Forest Plot is the result of a meta-analysis that has been done and contains the names of studies as well as the amount of effect size of each study and there are confidence intervals at the lower and upper limits. Based on the Forest Plot image above, it can be explained that the more towards the right, the higher the size of the effect, while for the size the larger the box, the greater the level of significance. Likewise, there is an estimated value in the forest plot. So from the image, it means that the effect size that has been analyzed varies with magnitudes between 16.61 to 96.34.

Investigating Publication Bias

Studies with good or good meta-analysis design if there are no problems with publi-cation bias so that publication bias investigations must be carried out. The following investi-gation of publication bias is carried out by:

1. Funnel Plot

   Based on the results of data processing, the following funnel plot image is obtained:

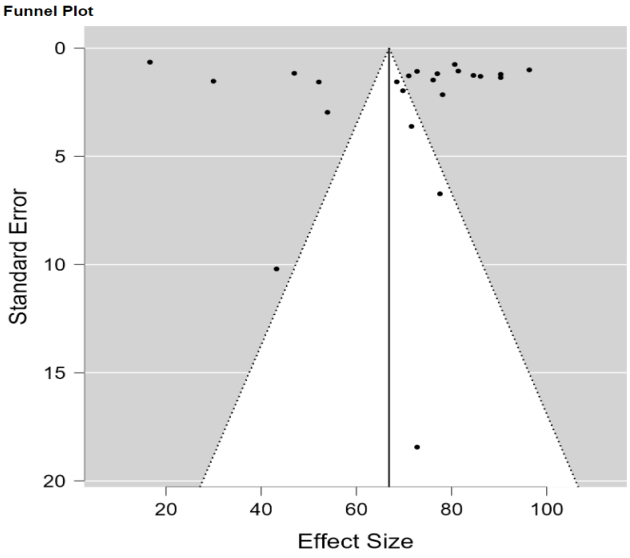


Figure 5. Funnel Plot

   The funnel plot image explains that the points spread around the mean on the right and left sides with the points not collecting in one place but cannot be stated whether the shape of the image is symmetrical or not so that the Egger's test method and drawer analysis file are needed to prove that the image is symmetrical and does not have a publication investigation bias.

2. Egger's test

   This method is a way that can explain that for the image form in the funnel plot, the following table is Egger's test study:

Table 6. Egger's test

Regression test for Funnel plot asymmetry ("Egger's test")		
	z	p
sei	-0.075	0.940

   Based on the table above, the amount of p = 0.940 then the amount of p value is >0.05 which means that the funnel plot is symmetrical which means there is no publication bias in the meta-analysis study.

3. File Drawer Analysis

Here's the Table for investigation of publication bias in File Drawer Analysis:

Table 7. File Drawer Analysis

File Drawer Analysis

	Fail-safe N	Target Significance	Observed Significance
Rosenthal	455535.000	0.050	< .001

From the existing table, the value of Failsafe N is 455,535, meaning that it is suspected that there may be studies that are biased in a publication then the data is compared with Rosenthal's formula, which is 5K + 10, because K = 24 then 5 (24) + 10 = 120 + 10 = 130. The results of 130 have a smaller value than Fall safe N so there are no problems in the meta-analysis studies that have been done.

Based on the approach that has been taken, namely funnel plot, egger's test, and drawer analysis file, it can be interpreted that there are no problems in publication bias so that this metanalysis research has accountable results, namely the blended learning model is effective in developing students' critical thinking skills in learning.

DISCUSSION OF FINDINGS

Blended learning is an innovative learning model that is currently suitable for appli-cation in education. By looking at technological advances, of course, education can use this technology to achieve the goal of improving the quality of students and teachers. It is a very important priority for students to acquire knowledge, conceptual understanding, skills, and abilities in the fields of technology, media, and information (Firmansyah, et al., 2019; Pahrudin et.al, 2021). The learning process by utilizing information and communication technology is guidance from teachers to facilitate effective learner learning. The use of learn-ing media in the teaching and learning process can generate new interests and desires, gener-ate motivation and stimulation of learning activities, and even bring psychological influences on students. (Yuliana et.al, 2020). Education with technology is important today in its application. The variety of methods, media, and learning resources using advanced technology such as the internet is massive.

The blended learning model is a mixed model used between conventional and online. We define blended learning as intentional learning a combination of online and class-room-based activities designed to activate and support learning, where we distinguish between synchronous (those with real-time participation of all participants) and asynchronous (which take place in a different time and space for each participant) in online learning activities (Boe-lensetal, 2017; Bruggemanetal., 2021; Hrastinski, 2019; Maggio et al., 2018; Tomej, 2022). Students are at a certain distance from educators or instructors and use some form of computer-based technology to access teaching materials as well as to interact with educators or instructors and other learners (Sulistyanto, 2021)

Seeing this, there are several advantages to using blended learning. Blended learn-ing offers both advantages and challenges for participants. It is flexible in terms of space and time for learning activities to suit the needs of many adult learners. This type of flexibility in-creases the availability of adult education and training, thus enabling learning for more peo-ple, e.g. in rural areas far from teaching institutions, or people in part-time or even full-time jobs. The use of blended learning also holds the promise of building networks between partici-pants that can serve as important support for lifelong learning. Some challenges, on the other hand, can work as obstacles for participants. One is the increased learning 'load' that comes with the need for basic IT literacy and online communication skills, etc. In addition, not only learners but

also teaching staff need training to facilitate online interaction and learning, as well as the production of high-quality digital learning materials (Georgsen & Løvstad, 2014).

Skills in this 21st-century era, one that must be mastered is the ability to think crit-ically. The ability to think critically is stated as an essential skill in 21st-century society so it must be integrated into the learning process (Dewi, et.al., 2021) Students with all challenges in the future must have competence in both mastery of technology as well as cognitive, affective and psychomotor aspects. In this case, innovative learning with current technology provides convenience and breadth for humans to learn. The innovative learning process is expected to foster students' critical thinking skills (Legowo, et.al., 2019; Fida & Liya, 2020). Critical thinking involves the ability to evaluate problems so that good conclusions can be drawn (Burke et al., 2014). Therefore, oral abilities and critical thinking skills need to be (Wulandari et al., 2018) possessed by students. The results of the study have shown that the blended learning model is effective for developing critical thinking skills so that as a technology that supports educational activities it benefits the process of achieving the goals of 21st century education by thinking critically. The two variables are interlinked with their meanings. Like it or not, like it or not, blended learning positively correlates with critical thinking skills in eve-rything. The basic elements of the stages of critical thinking skills, namely (Arends, 2012; Ministry of Education and Culture, 2018), namely:

Table 8 Basic elements of Critical Thinking

Element	Definition
Focus	Well identified problems
Reason	The reasons given are logical or not to be concluded as determined in the matter
Inference	If the reasons developed are correct, then they must be sufficient to arrive at the actual conclusion
Situation	Compared with the actual situation
Clarity	There must be clarity of terms and explanations used in arguments so that there are no errors in drawing conclusions
Overview	Checking something that has been found, decided, noticed, studied, and concluded

The blended learning model is one of the efforts to achieve learning objectives spe-cifically and in general, namely educational goals. With students experiencing blended learn-ing, learning can grow and develop critical thinking skills so that they can develop well.

CONCLUSION

The study of blended learning with critical thinking skills was designed with a meta-analysis with 24 selected articles resulting in a determined effect size, namely the average has high heterogeneity. Then from data analysis, it is explained that the blended learning model is effective in developing students' critical thinking skills in learning. This has been well tested and there are no problems in investigating publication bias. For this reason, it is proven that technology is able to coexist with education and sustain the success of its goals. From this re-search can also be done with a wider study and a larger number as well as coverage of the area so that the results of the research will increase in variety and known usefulness. Blended learning is an option in learning supported by various components, so critical thinking skills can develop and improve well.

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