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Blended Learning and Student Mathematics Ability in Indonesia: A Meta-Analysis Study

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Currently, masses of studies on mathematics learning getting to know have been discovered in numerous literatures supported by the use of blended learning model. This meta-analysis study aims at determining the overall effect of using blended learning. This study analyses 36 effect sizes from ERIC documents, Google scholar, and repositories from 2012 to 2021, overlaying a total of 1255 students. To support calculation accuracy, JASP software is used. effect size is decided with an appropriate confidence level of 95%. This study found that the effect size generated using the random effects model was 1.269 (Very High Effect). This finding shows that on average, students in Indonesia who use blended learning effectively can improve their math skills. This study finds out how far the effect of the use of blended learning on students' mathematical abilities and provides information for the use of the next blended learning model.

Keywords: mathematics, mathematics ability, blended learning, meta-analysis, effect size

INTRODUCTION

Mathematics is one of the exact fields of science that is more concerned with student understanding than memorization. Mathematics plays a very important role for students and society in general. At school, mathematics is needed for counting, measuring, processing, presenting and interpreting data and so on. Because it has important benefits in life and is needed as a basis for studying advanced mathematics and other subjects, mathematics is an important subject to be taught in schools. Mathematical ability is an important prerequisite for school performance and career success (Bochniak, 2014). Some research showed that students who have mathematical abilities double their

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chances of achieving a bachelor's degree (Adelman, 2006). These results clearly indicate that the mastery of mathematical skills has a very important role for students.

Mathematical ability of Indonesian students remains below expectations evaluate to that in different countries. According to the results of the 2018 Program for International Student Assessment (PISA) study, the mathematical ability of Indonesian students has only been ranked 72 out of 79 countries with an average score of 379 which means lower than that in 2015 Indonesia which was ranked 63. Meanwhile, based on the results of the TIMSS (2015) study (Trends International Mathematics and Science Study), students' mathematics achievement in Indonesia is still far below the international average. Indonesia is ranked 44th out of 49 countries in the world with an average score of 397 out of an international average score of 500.

To overcome the relatively low mathematical ability of Indonesian students, it is necessary to have the latest learning innovation that is able to provide opportunities for students and teachers to carry out off-class learning sufficiently. The need for a concept and mechanism for information technology-based education becomes something that needs to be done to make learning more developed and more enjoyable. One of the learning models that are in accordance with the development of current conditions is the blended learning model. The blended learning model is considered to be able to affect mathematical achievement (Ningsih et al., 2017; Aritonang & Safitri, 2021; Siregar & Manurung, 2020; Mutaqin et al., 2016). Blended learning combines traditional face-to-face models with e-learning models, so as to create a richer learning experience (Usta, 2007; Akkoyunlu & Soylu, 2008).

Several research in Indonesia showed that the blended learning model is effective in learning mathematics (Yaniawati, 2012; Supriadi et al, 2014; Sudiarta & Sadra, 2016; Jayanti & Rahmawati, 2017; Pertiwi, 2018; Darmono & Maryam, 2019; Siregar & Manurung, 2020; Aritonang & Safitri, 2021). The results of other studies conducted outside Indonesia showed that blended learning can effectively improve mathematical abilities (Tseng et al, 2014; Lin et al, 2017; Alsalhi et al, 2019; Seage & Türegün, 2020). However, research conducted by (Farhatana et al, 2017; Chaney, 2013), his research showed inconsistent results. The research found that using blended learning is not better than using conventional learning. Findings from various studies that give different results can lead to errors in building conclusions (Demirel & Dagyar, 2016; Franzen, 2020).

To fill this gap, efforts are needed to integrate the main findings to provide useful information for policy making (Higgins and Katsipataki, 2015; Siddaway et al, 2019). Consequently, a meta-analysis study is wanted that consists of all the principle studies at the above-mentioned subjects with the goal of integrating and decoding the findings to achieve in-depth and convincing conclusions (Schmidt & Hunter, 2015; Tamur & Juandi, 2020).

A meta-analysis study is needed to assess the effectiveness of using the blended learning model on students' mathematical abilities compared to traditional teaching in mathematics. In addition, this study is also to determine the extent of the influence of the

use of blended learning on students' mathematical abilities. The findings of this study are expected to contribute to the literature that provides important information for further use of blended learning model.

Literature review

Adas and Shmais (2011) see blended learning as a method that creates a suitable learning environment for high school students. Blended learning that combines these two learning environments provides many advantages for students and teachers (Brown 2003; Singh & Reed, 2001). Blended learning can be seen as a combination of learning that combines web-based, video, audio, synchronous, and asynchronous communication with face-to-face learning (Quevedo, 2011). The basic principle of blended learning is face-to-face and online, activities are optimally integrated into a unique learning experience consistent with the context and learning objectives (Garrison & Vaughan, 2008). This model can be carried out not only during the face-to-face learning process, but also during activities outside face-to-face activities, either at school, at home, or at other places with internet access. Blended learning will increase student-teacher and student-student interaction, and provides an extra dynamic and interactive learning environment, which ends up in a better level of participation (Donnelly, 2009). Moreover, it provides learners with additional learning opportunities and facilitates them to achieve deeper and extra significant learning levels and to resolve complicated issues (Patrick & Sturgis, 2015). Further, learners in the blended learning model can show their capability to reflect themselves socially and academically within the virtual learning environment as well as in face-to-face learning. In today's world, as lifelong learning becomes very important, the acquisition of digital learning skills becomes imperative in order to be lifelong learners. In addition, the blended learning model facilitates learners enhance their skills to use numerous information technologies, and allows individuals to make progress toward turning into technologically literate (Cleveland & Wilton, 2018). on this appreciate, it is able to be said that it will be useful to apply the blended learning model in teaching and learning to perform the academic output and comprehensive learning revel in.

According to Garrison (2013) within the context of school learning, the use of online learning technology offers several advantages compared to face-to-face learning. In contrast to spontaneous verbal communication in a typical face-to-face learning environment, a blended learning model provides learning on environment where written communication occurs asynchronously can provide conditions that promote reflective questioning. In the learning process, blended learning requires suitable media for its application. One of the media that supports blended learning is the Moodle application media. Moodle is one of the Learning Management System (LMS) applications that are widely used in online learning. With Moodle application, text, graphics, animation, simulation, audio and video can be entered. Media that can display animation is a medium that can reduce difficulties for students to receive learning materials. The use of Moodle in the learning process that uses blended learning can explore abilities and create attractiveness for students to learn (Sandi, 2012)

Another media that supports blended learning is Edmodo. Edmodo is a worldwide education network that facilitates connect all learners with others and the sources had to attain their full ability (Ardana, 2016). Edmodo is a secure social networking community and provides an educational blogging microenvironment for teachers and students which can also be seen as a multi-platform learning management system (LMS) that can facilitate educators to easily manage and manage their online classes (Witherspoon, 2011). Edmodo creates a safe environment for teachers and students in many ways in learning such as cooperation, feedback, and so on, giving students the freedom of time and place to study, as well as helping to control students and enabling them to share their knowledge and ideas with the following features: features in it. Edmodo allows teachers and students to communicate with each other through messages, thereby offering participants with the possibility to communicate and collaborate in a digital classroom surroundings (Balasubramanian, Jaykumar & Fukey, 2014; Ekmekçi, 2016; Mokhtar, 2016). Edmodo is one of the popular and most preferred educational social platforms having around 48 million users worldwide (National Centre for Education Statistics, 2008).

METHOD

This study uses meta-analysis method to evaluate statistically the findings that examined the effect of blended learning model on the mathematical ability of students in Indonesia. Meta-analyses provide an universal evaluation through statistical analysis of quantitative data acquired in independent research on unique topics (Cleophas & Zwinderman, 2017; Glass, 1976; & Schwarzer et al., 2015). Effect size is a easy way to measure differences among two groups, which has many benefits over the usage of statistical significance tests alone (Coe, 2002; Ellis, 2010; Thalheimer & Cook, 2002). The stages of meta-analysis in this study followed Borenstein et al. (2009) namely; 1) determine the inclusion criteria for the analysis, 2) procedures for collecting empirical data and coding study variables that will be explained, 3) statistical techniques to explain the analysis.

Eligibility criteria

All articles being studied in this study in at the initial search had been examined and assessed for inclusion inside the meta-analysis using the subsequent eligibility criteria: 1) publication year range 2012 to 2021, 2) articles involving Indonesian authors and published in international, national, or international journals or proceedings, or those indexed by SINTA, 3) research articles have at least one experimental class using blended learning and the others are conventional classes or others as control classes, 4) all articles being studied report sufficient data to transform effect sizes.

From the search results determined 36 research publications that meet the standards distinct above with a publication time span from 2012 to 2021 (Table 2).

Data collection

Empirical data in this study comprises all articles/studies about the effect of using blended learning on students' mathematical abilities in Indonesia. Data were

identified/gathered from online databases ERIC, SAGE, SpringerLink, and Google Scholar. Keywords used in collecting research studies/articles include "students' mathematical abilities", "blended learning", "effects of blended learning on students' mathematical abilities", "implementation of blended learning", and their equivalents in Indonesian.

Statistical analysis

The unit of analysis in the meta-analysis is the effect size (Glass, 2015). The size of the effect in this study is an index that describes the magnitude of the influence of the use of blended learning on the mathematical ability of students in Indonesia. The statistical procedure in this study followed Borenstein et al. (2009) namely; (a) calculating the effect size of each primary study, (b) perform heterogeneity test and selection of estimation model, (c) check for publication bias, and (d) calculate the p-value to test the research hypothesis. For data analysis this study uses JASP program. Table 1 shows the effect size classification criteria using Thalheimer and Cook (2002)

Table 1
The effect size classification criteria

Effect Size	Category
Between -0.15 and 0.15	No effect,
Between 0.15 and 0.40	Low effect,
Between 0.40 and 0.75	Medium effect,
Between 0.75 and 1.10	High effect,
Between 1.10 and 1.45	Very high effect,
1.45 or higher	Amazing effect

The heterogeneity test turned into accomplished by means of analyzing the Q statistic and p value. If the p cost <0.05, the null hypothesis which states that the effect size of each study is homogeneous is rejected. Thus, the estimate chosen is a random-effect model. If the p value> 0.05 then the null hypothesis is accepted and the fixed-effect model is evaluated. An analysis of the study's level of variation by examining moderator variables is carried out after it was determined that the estimate chosen is a random-effect model.

An examination of publication bias is accomplished to prevent misrepresentation of the findings. published research are more likely to be covered within the meta-analysis than their unpublished opposite numbers, and this has brought about issues that meta-analyses may overestimate the true effect size (Borenstein et al., 2009; Tamur, Jehadus, Nendi, et al., 2020). To assume this, funnel plots are tested to evaluate the feasible quantity of bias, and Rosenthal's FSN statistics (Tamur, Juandi, & Kusumah, 2020) are used to evaluate the effect of bias. This study is stated to be immune to bias if the spread of effect sizes indicates a symmetrical distribution across the vertical line (Borenstein, Hedges, & Rothstein, 2009). If the effect sizes are not completely symmetrically distributed then Rosenthal's fail-safe statistic N (FSN) is used. If the value of FSN / (5k + 10) > 1 where k is the number of studies included in the meta-analysis then this study is resistant to publication bias (Mullen et al., 2001).

FINDINGS AND DISCUSSION

Based on the results of the analysis of 36 studies/articles, the effect size and standard error of each study are presented in Table 2 below.

Table 2
Effect size and standard error of each study

No	Author	Year	Effect Size	Standard Error
1	Ningsih, Y. L et al	2017	2.12	0.36
2	Aritonang, I & Safitri, I	2021	3.35	0.38
3	Yanti, F. N et al	2019	0.50	0.26
4	Nugraha, D. G. A. P et al	2019	0.68	0.25
5	Mutaqin, A et al	2016	1.54	0.31
6	Siregar, N & Manurung, S. L	2020	2.98	0.36
7	Yaniawati, R.P	2012	0.31	0.15
8	Anggraini, E	2018	1.26	0.28
9	Septian, I et al	2019	0.41	0.26
10	Darmono, P, B & Maryam, I	2019	0.95	0.29
11	Sudiarta, I G, P & Sadra, I W	2016	1.44	0.26
12	Dewi, H. L & Biladina, S.G	2021	0.63	0.26
13	Trisnayanti, N.P.E et al	2020	1.86	0.29
14	Apsari, N.P.D.M	2020	2.54	0.30
15	Nugraha, S.A et al	2020	0.09	0.40
16	Jayanti & Rahmawati	2017	1.37	0.26
17	Farhatana et al	2017	-0.07	0.25
18	Khairiyya, A et al	2020	0.25	0.35
19	Zein, M et al	2019	0.78	0.26
20	Satriani, R.D et al	2020	1.60	0.27
21	Supriadi, N et al	2014	2.74	0.35
22	Nida, N.K et al	2020	1.12	0.17
23	Ulfa, M & Puspaningtyas, N.D	2020	1.37	0.28
24	Setyaningrum, W	2018	0.45	0.18
25	Fisher, D	2017	0.51	0.23
26	Pertiwi, A et al	2018	0.91	0.25
27	Hidayati, A	2021	0.87	0.28
28	Setiyani	2019	0.80	0.33
29	Sari, D.P	2019	1.41	0.28
30	Sari, M et al	2020	1.58	0.36
31	Detiana et al	2020	1.81	0.32
32	Mashuri, S & Nasrum, A	2020	1.49	0.35
33	Tsaniyah, F.S et al.	2019	0.73	0.26
34	Ektafia, F et al	2021	1.78	0.29
35	Bainamus, P. M et al	2016	1.50	0.27
36	Asyrofi, M & Junaedi, M	2016	2.69	0.32

Based on Table 2, the overall effect size ranges from -0.07 to 3.35. According to the effect size classification by Thalheimer and Cook (2002), out of 36 effect sizes, two effect sizes (5.56%) are classified as having no effect; two effect sizes (5.56%) are

classified as low, seven effect sizes (19.4%) are classified as moderate effects, five effect sizes (13.89%) are classified as high effect, six effect sizes (14.36%) are classified as very high effect, and fourteen effect sizes (38.89%) are classified as amazing effect. Furthermore, a suitable model will be investigated to estimate the mean effect size of the 36 studies being analysed. Table 3 shows the results of the Fixed and Random Effects model.

Table 3
Fixed and random effects

	Q	Df	P
Omnibus test of Coefficients Model	86.355	1	< .001
Test of Residual Heterogeneity	279.146	35	< .001

Note. p -values are approximate

Based on Table 3, the results of the analysis show the Q value of 279.146. This value is found to be greater than 86.355 within 95 degrees of freedom in the distribution table 2 and $p < 0.001$. So, it can be concluded that the distribution of the effect size on the analysed studies is heterogeneous. Thus, the random effects model is more suitable for estimating the mean effect size of the 36 studies being analysed.

Furthermore, the issue of publication bias will be evaluated against the 36 studies being analysed. To assess the possibility of publication bias problems, we can analyse the funnel plot and calculate the Rosenthal fail-safe N (FSN) value (Borenstein et al., 2009a, b; Tamur and Juandi, 2020; Yunita et al., 2020; Suparman et al., 2021a, b). Figure 1 shows the diagnostic results of the funnel plot.

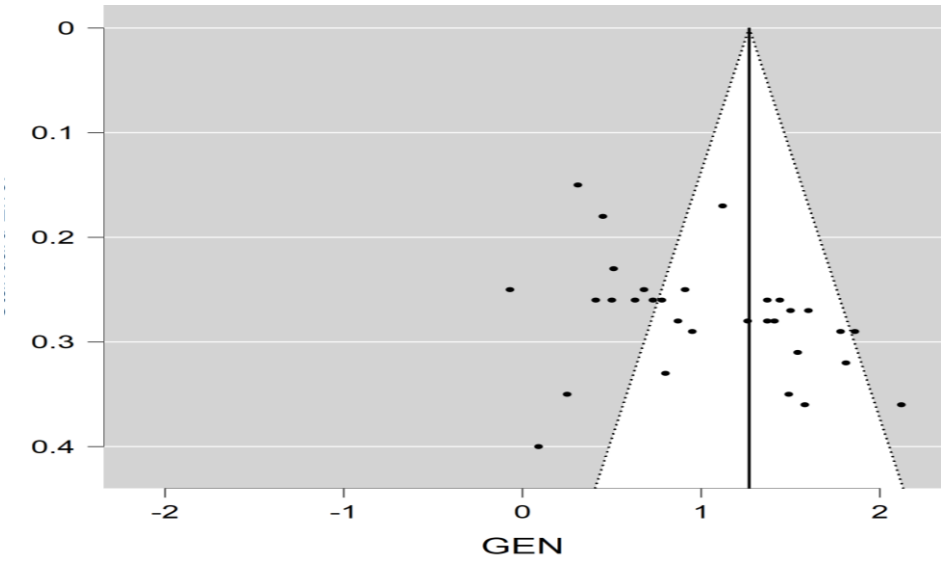

Figure 1
Funnel Plot Random Effect Model

In Figure 1, the results of the funnel plot are difficult to conclude whether the funnel plot is symmetrical or not, so it is continued by calculating the Rosenthal's fail-safe N (FSN) value. The following diagnostic value for fail-safe N Rosenthal is shown in Table 4 below.

Table 4
Fail-Safe N

File Drawer Analysis			
	Fail-safe N	Target Significance	Observed Significance
Rosenthal	9093.000	0.050	< .001

Because the value of K = 36 so 5K + 10 = 5 (36) + 10 = 190. The Fail-Safe N value obtained is 9093 with a target significance of 0.05 and $p < 0.001$. Because the File-Safe N value is > (5K + 10), it can be concluded that the meta-analysis study carried out do not have publication bias problems and could be justified scientifically. Furthermore, Table 5 shows the results of the average effect size of the 36 studies being analysed.

Table 5
Summary/mean effect size

Coefficients						
	Effect Size	Standard Error	**z**	P	95% Confidence Interval	
					Lower	Upper
Intercept	1.269	0.137	9.293	< .001	1.001	1.536

Note. Wald Test

The results of the analysis in Table 5 using the random effects model, the 95% confidence interval has a lower restrict of 1.001 and an higher restrict of 1.536, and the general effect size of the analysed research is 1.269. This effect size belongs to the very excessive effect category. The results of the calculation of the z test to determine statistical significance obtained a z value of 9.293. This result may be stated to be statistically significant at the level of $p < 0.001$. Thus, the application of blended learning has a positive and greater impact on students' mathematical abilities than using a conventional approach.

This study is in line with Tsai et al. (2018) that Blended Learning can improve self-efficacy, and have an impact on learning independence. This finding corresponds to Halverson (2016) that Blended Learning enhances learning pleasure and confidence. Blended Learning changes the paradigm from teaching to teaching, then makes students more active in learning so as to increase perseverance and commitment (Kashefi et al.. 2018). Blended Learning provides diverse learning resources such as videos, animations and images, so it is very different from the learning environment in the classroom with limited learning media and learning activities. Therefore, Blended Learning makes students more motivated and their self-regulated increases. Moreover, students prefer to have discussion outside the classroom, because is less pressure and more comfortable so students who have low self believe will be sophisticated.

Blended learning has the advantage of being accessible anytime and anywhere. Online social interaction leads to positive and productive communication in the form of information exchange (Mustapa et al., 2015). Online discussions and face-to-face discussions contribute to the overall learning experience. Blended Learning changes the paradigm from teaching to learning, thereby enabling students to become more involved in the learning process and more enthusiastic and, consequently increasing their persistence and commitment (Ismail et al. 2018).

CONCLUSIONS AND SUGGESTIONS

The distribution of the effect size on the analysed studies is heterogeneous. The overall effect size ranges from -0.07 to 3.35 with moderate up to high and very high effect size bigger than the no effect and low effect size. The meta-analysis study carried out do not have publication bias problems and could be justified scientifically. The results of the analysis show that the application of blended learning has a huge positive impact on college students' mathematical capabilities compared to the conventional approach. Although these findings indicate that the application of blended learning has a large effect on students' mathematical abilities, these findings are only based on 36 studies/articles. There are also a few other research that cannot be evaluated due to constrained methodological knowledge. Therefore, it is recommended to conduct future research by broadening data collection further to obtain other necessary affected variables.

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