OmniaScience

Journal of Technology and Science Education

JOTSE, 2023 – 13(3): 694-717 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349

https://doi.org/10.3926/jotse.2138

THE IMPACT OF ONLINE LEARNING ON THE MATHEMATICS LEARNING PROCESS IN INDONESIA: A META-ANALYSIS

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Received February 2023

Accepted June 2023

Abstract

The goal of this meta-analysis is to ascertain how online learning has affected Indonesian students' ability to learn mathematics. Descriptive analysis was used to compile info from 41 pieces of information about the research, such as sample size, standard deviation, mean values for the experimental and control groups, and other data. Data analysis methods include testing for heterogeneity, effect size calculations, summary outcome calculations the random effect models, and publication bias identification. Forest plots are used as the data source for the meta-analysis. The outcomes revealed that the impact of online learning in Indonesia was 1,268 which had a high influence on the education process of student mathematics. The online learning model also has a higher impact at the primary school level than at the middle school, high school, and university levels. The research area in Indonesia that has the biggest impact is the province of North Sumatra. A sample size of more than 30 gives a greater effect than a sample size of 1-30.

Keywords – Impact, Online learning, Mathematics learning, Meta-analysis.

To cite this article:

Turmuzi, M., & Lu'luilmaknun, U. (2023). The impact of online learning on the mathematics learning process in Indonesia: A meta-analysis. *Journal of Technology and Science Education,* 13(3), 694-717. https://doi.org/10.3926/jotse.2138

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1. Introduction

Due to the COVID-19 pandemic, new words have entered everyday speech and novel situations, including distant learning, have become commonplace (Cao, Fang, Hou, Han, Xu, Dong et al., 2020; Händel, Stephan, Gläser-Zikuda, Kopp, Bedenlier & Ziegler, 2020; Owusu-Fordjour, Koomson & Hanson, 2020). Due to school and university closures, there are now more than 1.5 billion homeschoolers worldwide (UNESCO, n.d.). Numerous research (Ali, 2020; Bao, 2020; Kapasia, Paul, Roy, Saha, Zaveri & Mallick, 2020) concentrated on how schools responded and how online classrooms operated.

Online education has a significant impact on changing both students' and teachers' habits in Indonesia. They must start by adjusting to the environment of online learning. This is due to a change from face-to-face communication instruction at schools the Internet instruction. To create active learning environments, it's critical to look at the aspects that influence online learning (Ćukušić, Alfirević, Granić & Garača, 2010). For the institutions to create suitable plans, this is essential.

With its variety of communication services, the internet—a fast-expanding communication network—has emerged due to the access, sharing, storage, and use of information-generating actions in the modern period and has become an increasingly important structure for education and training (Tezer, Yildiz, Bozkurt & Tangul, 2019). A lot of advances in teaching and learning methodologies have been realized in tandem with today's developing technologies and shifting needs. Using online learning environments in the classroom is one of these advances.

Online learning environments, also known as Web-based learning environments are models for education. where learning and training exercises are controlled autonomously, regardless of time and location, and the computer is utilized as a tool for communication, research, and inquiry. Between learners-learners and learners-educators, communication activities are carried out in this context on the internet. In online learning environments, interactive pages simplify the processing of the lesson and raise the standard of instruction. Discussion boards, network sites, extra software, a virtual classroom, forums, multimedia programs, video conferencing, as well as teleconferencing are some examples of the tools that make it possible for learning activities to be supported by the web (Tezer & Çimşir, 2018).

This scope includes the web-based remote education concept as well. Nearly every strategy or tactic employed in the field of online distant learning is utilized in this educational style. The ability to provide asynchronous (asynchronous) instruction, allowing users to access system material whenever they want it, and allowing users to use resources to the amount necessary to achieve their objectives are the three main benefits of web-assisted distance learning. The ability to build optimum learning environments is made possible by the combination of such flexibility and cost-saving benefits (Carswell, 2002).

To further understand how and when these tools are successful, numerous Studies on the effects of mobile learning have been conducted technologies on student achievement. (Sung, Chang & Liu, 2016) assert that while the benefits of portable learning environments are highlighted, other factors can affect how mobile devices affect academic attainment. Research on the impact of different mobile gadgets on education has produced conflicting findings in this area. For instance, (Goodman, Seymour & Anderson, 2016) examined student performance on problems involving spatial mathematics that were both physical and digital. After their research, it was discovered that physical representations of spatial tasks were more successful. Different findings on the usefulness of mobile education according to grade level have been provided in other studies. For instance, (Güler, Bütüner, Danişman & Gürsoy, 2022) found that, compared to face-to-face apps, mobile learning tools considerably boosted the academic success of university students. At the same academic level, (Hung, Yang, Fang, Hwang & Chen, 2014) did not get a verdict that indicated such efficiency. Last but not least, (Tingir, Cavlazoglu, Caliskan, Koklu & Intepe-Tingir, 2017) argued that the implementer's role may be more important than previously thought in their meta-analysis study that sought to establish the impact of mobile devices on K–12 students' achievement. They discovered that several studies showed a larger impact size when the instructor implemented them instead of studies carried out by academics.

Furthermore to these erratic findings, past meta-analysis research such as Talan (2020) shows a stronger emphasis on general education than on subject domains. This paper made an effort to do a meta-analytic comparison of student achievement in regular classrooms and mobile mathematics learning environments while taking all of these considerations into account. In this view, a typical classroom is a setting for learning where teachers engage students through a range of methods, such as lectures, group projects, and presentations. In contrast, mobile learning includes educational and information technology settings that are both within and outside of schools that allow students to whenever and wherever possible (Keengwe & Bhargava, 2014). We didn't examine the limitations of this broad concept because the meta-analysis is the current study and instead concentrated on the impact of environments described based on mobile learning environments. In a nutshell, the current study's goal is to close the aforementioned knowledge gap by addressing the following research questions, which were prompted by the design of this study to look at the state of cognitive learning outcomes of students during mobile-based instruction:

1. What effect does online instruction have on Indonesian students' learning of mathematics?
2. What moderator factors (Impact outcome, Indonesian territory, Sample size, Types of online learning) affect how well pupils learn mathematics when online-based instruction is used?
3. How does publication bias affect the effect sizes reported in this meta-analysis?

2. Methodology

2.1. Research Design

This study is a meta-analysis study. A meta-analysis integrates data from different studies on a specific topic to make generalizations. A statistical method called meta-analysis analyses the quantifiable findings from various studies to create larger and more generalized conclusions (Picardal & Sanchez, 2022; Hunter & Schmidt, 2004). A method for methodically evaluating empirical data and determining causal correlations is meta-analysis (Rosenthal, 1991). The meta-analysis approach offers effective measurement by blending information from research on the same subject carried out at various times and places. This meta-analysis evaluates how online learning has affected Indonesian students' ability to study mathematics. Google Scholar searches for related articles in Science and Technology Index (SINTA) and garba rujukan digital (GARUDA)-indexed publications.

2.2. Data Source and Search Strategies

This meta-analysis used the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) (Picardal & Sanchez, 2022; Badeo & Duque, 2022; Hak, Van Rhee & Suurmond, 2018) guidelines to identify eligible research studies. In searching for research studies for this meta-analysis, researchers used three (3) databases, namely Google Scholar, Science, and Technology Index (SINTA), and Garba Referral Digital (GARUDA). Appropriate keywords were typed in the three databases to identify eligible research studies. Keywords such as "online learning", "e-learning", "maths learning", "Impact of online learning", "online learning effect", and "experimental research" were used to prune the number of research study searches in the three databases. Furthermore, this study had pre-defined eligibility criteria to select the most eligible research studies in particular. The subsequent stage is to gather research data based on independent variables, such as the conventional learning model utilized by the control group and the online learning model utilized by the experimental group. The dependent variable is the outcome of the pupils' mathematical learning process. Then, from the search results once more, studies that matched the criteria were found. Quasi-experiments and the results of the study of descriptive data, including sample size, mean for both, and standard deviation of experimental and control learning, was used to identify the type of research. The flowchart that follows shows how to discover relevant research literature using these criteria. This graph was altered from an original by (Ridwan, Hadi & Jailani, 2022; Güler et al., 2022).

2.3. Inclusion Criteria

The criteria used for inclusion in the meta-analysis study adapted from Badeo and Duque (2022) are given below in detail:

1. The study had to use online learning in the learning process of mathematics.
2. Involve a research-experimental design with an experimental class group and a control class group.
3. Participants must be junior high school, high school, and college students.
4. Should consider the impact or effect of e-learning in the learning process of mathematics as the independent and dependent variables in this research
5. The assessment tools used in the study must have an adequate level of validity and reliability.
6. Report quantitative data for the experimental and control groups including sample size, mean scores of experimental and control classes, standard deviation (SD), and duration of implementation.

7. There are no geographical restrictions, but articles must be published in peer-reviewed journals from 2016-2022.
8. Articles with incomplete data based on the inclusion criteria were excluded.

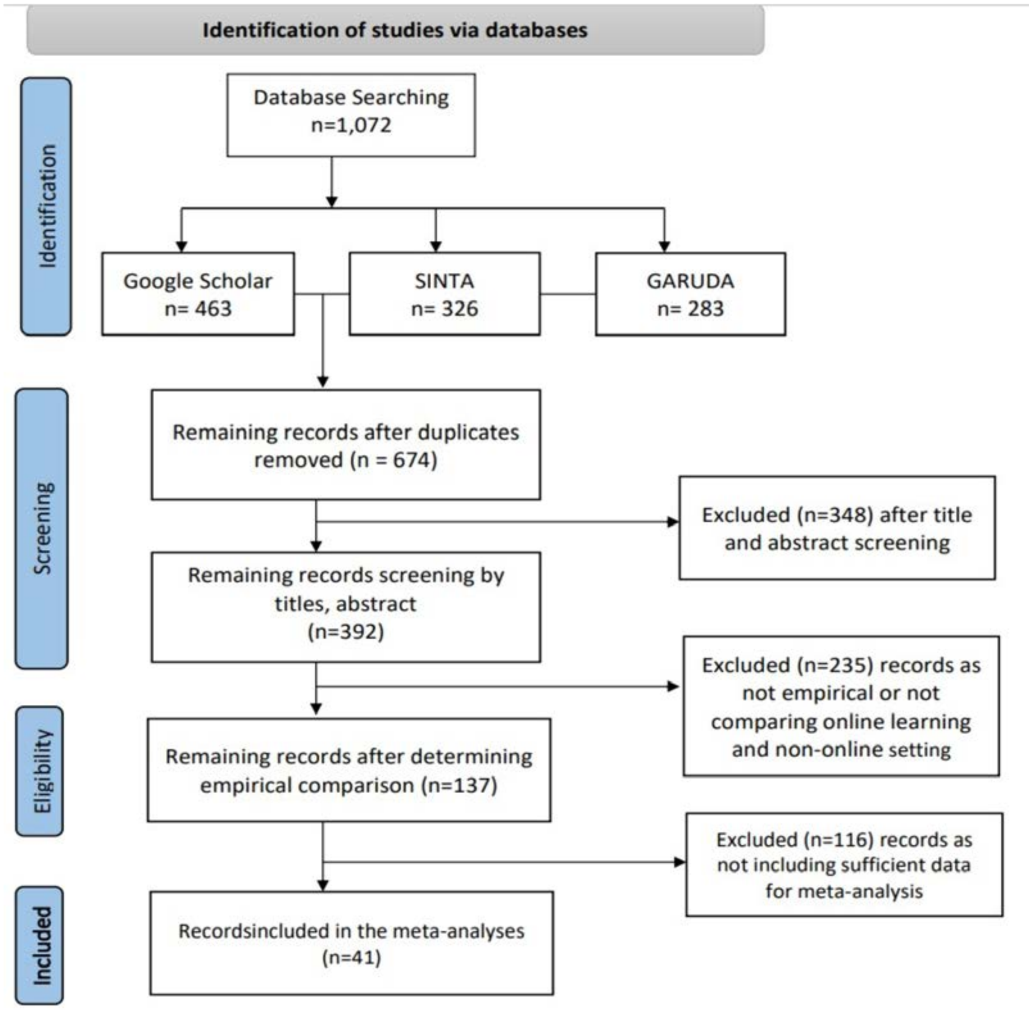

Figure 1. PRISMA was used to select research studies

2.4. Data Analysis

To reveal and generalize the results of previous investigations, this work combines meta-analysis with forest plot analysis. This research reveals the impact of online studying and how well students are doing in the math process. Both groups were investigated, and their learning impact was evaluated. The forest plot approach was used to generate based on each meta-analysis sample's impact size and summary effect values. In Forest Plot analysis, the software used is JASP Tools version 0.16.3.0. The education impact regarding the dependent variable can be calculated by adding the size of the sum effect estimate, z estimate, and p-value. Reject the notion that the efficacy If the estimated z is different between the two learning models value is less than 0.05 and the anticipated overall effect size is 0. The heterogeneity test was performed before the analysis of a forest plot.

The result of the heterogeneity test was whether the meta-analysis used a random or fixed effects model. Test for heterogeneity can use Q, τ^2, or I^2 (Retnawati, Apino, Kartianom, Djidu & Anazifa, 2018). The p-values of τ□^{2} and I^2 from Q-statistical analysis were employed in this study's heterogeneity test. The heterogeneity requirement states that there are several data distributions in the meta-analysis data set (Lipsey & Wilson, 2001). When the p-value is less than the level of significance, the heterogeneity test condition is satisfied. The following test employs I^2 for I^2 for 25% - 50%, 51% - 75%, and above 76%

with low, medium, and high heterogeneity levels (Borenstein, Hedges & Rothstein, 2009). Information about the distribution of the data is provided in depth by the statistical value for I^2. Parameter I^2, greater than 25%, indicates a great deal of the population's diversity and the true effect size.

Some of the key variables that are the focus of this research include: (1) Online Learning: This variable may refer to the use of digital technology and the internet to deliver learning materials, teacher-student interaction, and communication between students in the context of learning mathematics. (2) Mathematics Learning Process: This variable may describe essential aspects of the mathematics learning process, such as understanding of mathematical concepts, problem-solving skills, student engagement in mathematical discussions, and the use of effective learning strategies. (3) Impact of Online Learning: This variable relates to the impact of using online learning on the mathematics learning process. This impact may include an increase or decrease in learning quality, changes in student motivation and engagement, differences in student learning outcomes, and student and teacher perceptions of online mathematics learning. (4) Learning Context in Indonesia: This variable reflects the unique context of education in Indonesia, including technological infrastructure, limited internet access, socio-economic differences in students, education policy, and learning culture in Indonesia.

In a meta-analysis, researchers usually collect and analyze data from various relevant studies that have been conducted previously to draw broader conclusions. In this study, the researcher might investigate how online learning affects the learning process of mathematics in Indonesia based on the findings of previous studies.

3. Results

3.1. Effect of Online Instruction on Indonesian Students' Learning of Mathematics

In the literature search, 41 research papers were found, and the research example standards used the meta-analysis in were pseudo-experimental research, the use of learning with the online learning experimental class model, and the use of the traditional model as a control class. Based on the implementation of the two learnings and descriptive data analysis, the impact given will be analyzed as moderator variables, the following criteria are available: samples are taken, average, and standard deviation, too. Based on the meta-analysis analyzing the descriptive data of each study and evaluating the success and validity of online education models on the performance of the results of the mathematical learning process. Encoding data from research articles, heterogeneity testing, effect size calculations, forest plot analysis, and publication bias detection are all steps in the meta-analysis process. Coding research study data as a first step seeks to categorize data features in evaluating impact measures.

Utilizing numbers from an examination of the descriptive data of test results during the online mathematics education process in Indonesia, a meta-analysis of research results was formed. The results of descriptive data analysis were generated using a standard learning model as well as for control group an online learning model regarding the test group. Based on which research studies meet inclusion requirements, the data are categorized in the initial analysis of the study. The meta-analysis consists of a descriptive analysis of both groups and takes into account the average sample size, standard deviation, and each study. The coding findings of the various research results are summarized in Table 1.

Table 1 describes the results of the coding of the research data. The data in the table is the result of descriptive data analysis of student test scores against the results of the mathematics learning process with different learning models. While the control group followed traditional learning, the experimental group used online learning. To generate an estimate of the impact measure in this meta-analysis investigation, the SMD, or Standard Mean Difference calculated by multiplying the variance in the standard deviation between the mean of the experimental and control groups' scores.

Code	Researcher and Year of Research	Experiment group			Control group		
		Ne	Xe	SDe	Nc	Xc	SDc
A1	*Rangkuti, Sormin & Sahara (2022)	20	82.05	11.66	20	69.2	9.5
A2	*Nugraha, Sudiatmi & Suswandari (2020)	12	80.83	7.93	12	64.17	9
A3	*Pramesti & Cahyono (2021)	32	77.5	4.66	31	70.71	4.32
A4	*Imron, Affandi & Turmuzi (2020)	23	81.3	7.26	22	74.77	6.26
A5	*Ramdhani, Suharta & Sudiarta (2020)	32	82.03	9.23	31	68.55	8.77
A6	*Sudiarta & Sadra (2016) Study 1	37	91.21	6.49	38	82.63	5.29
A7	*Ibrahim & Suardiman (2014)	33	15.45	4.48	33	12.09	4.26
A8	*Zatalini, Minggi & Rusli (2017)	28	65.71	22.18	30	52.33	19.77
A9	*Soraya & Ria-Wantika (2021)	36	76.67	9.28	36	63.89	11.4
A10a	*Surat & Lian-Jayani (2019) Study 1	36	149.31	9.76	36	123.11	11.77
A10b	*Surat & Lian-Jayani (2019) Study 2	36	72	5.49	36	61.56	5.76
A11	*Kamal (2021)	32	80	12.95	32	74.06	14.61
A12a	*Suprihatiningsih, Harmini, Sudibyo & Annurwanda (2022) Study 1	30	76.47	8	30	58	8.04
A12b	*Suprihatiningsih et al. (2022) Study 2	30	65.03	7.85	30	58	8.04
A13	*Husna (2020)	21	42.64	1.49	21	37.41	1.4
A14	*Yensy (2020)	30	79.08	9.92	30	68.07	7.71
A15a	*Nugraha, Astawa & Ardana (2019) Study 1	34	11.08	3.29	34	8.88	3.16
A15b	*Nugraha et al. (2019) Study 2	34	8.02	2.97	34	6.32	2.53
A16	*Hanifah, Supriadi & Widyastuti (2019)	30	67.26	7.86	30	66.73	9.65
A17	*Sudiarta & Sadra (2016) Study 1	28	92.64	5.83	28	84.36	7.36
A18	*Aritonang & Safitri (2021)	34	90.41	6.78	34	65.56	7.83
A19	*Dewi, Suarsana & Juniantari (2020)	60	79.05	8.77	62	62.41	9.1
A20	*Tatulus, Sulangi & Salajang (2021)	28	84.13	4.44	30	79.23	9.39
A21	*Ramdana-Siling, Sridana, Kurniati & Sripatmi (2022)	33	65.15	10.86	33	59.24	11.33
A22	*Afrilian & Budiyono (2021)	36	75.08	3.82	36	56.06	6.96
A23	*Rahim, Bito & Resmawan (2022)	20	76.7	11.66	20	53.3	16.98
A24	*Hilyatul-Muniroh, Rojanah & Raharjo (2020)	30	75.23	10.33	30	67.87	8.87
A25	*Maryam (2018)	25	71.48	12.81	26	59.88	12.85
A26	*Sudiarta & Sadra (2016)	37	91.21	6.49	38	82.63	5.29
A27	*Indrawan & Anggreni (2019)	37	39.17	5.01	37	35.41	3.22
A28	*Suharti (2021)	22	89.52	5.41	22	85.5	6.35
A29	*Rosyidah (2022)	32	79	16.62	32	69	19.45
A30	*Trisnayanti, Sariyasa & Suweken (2020) Study 1	38	80.68	5.33	29	71	4.88
A31	*Lestari, Pratama & Sulistiowati, (2021)	117	80.03	15.34	117	70.67	15.55
A32	*Nasrullah, Ende & Suryadi (2017)	35	59.86	13.31	35	41.63	13.79
A33	*Haerunnisa, Abdillah, Pramita, Mahsup, Mandailina, Syaharuddin et al. (2021)	12	61.16	7.28	12	48.41	19,80
A34	*Millah & Shodikin (2021)	10	72	5.37	10	66	6.58
A35	*Sidabutar (2021)	25	90.1	6.12	25	84.5	6.65
A36	*Nasution, Susilawati & Wahyudi (2022)	31	14.49	2.85	31	9.52	3.62
A37	*Hermanto & Sukmarini (2022)	25	85.86	7.55	25	64.14	14.15
A38	*Trisnayanti et al. (2020) Study 2	38	104.13	6.53	29	97.27	7.79

Note. N=Sample size; Xe = Mean class experimental learning outcomes; Xc = Mean control class learning outcomes; SD= Standard deviation.
*Reference to the meta-analysis study

Table 1. Data coding results

Heterogeneity when using the meta-analysis method is related to faulty sampling or variations in findings among different research (Borenstein et al., 2009). To ascertain how much sampling error, population variance, and sizes in the study have a bearing on the conclusions of each research study, tests for heterogeneity must be run. The outcome of the heterogeneity test also determines whether the study uses either a random outcome model such as a fixed effect model. As a result, one of these effect models was used to generate the effect magnitude or summary effect of the study data for further analysis. In this work, the parameters I^2 and τ^2 that are provided in Table 2 were used to analyze heterogeneity testing using Q-statistics (with p-value).

	Test for heterogeneity parameter				
	Q-Statistic				
Dependent variable	**Value**	**df**	***p*-value**	$\boldsymbol{I^2}$	τ^2
Mathematics learning process	242.499	40	0.0010	86.137 %	0.476

Table 2. The heterogeneity test analysis results

According to the findings of the mathematics learning process test, Table 2 shows the outcomes of analyzing the research papers' heterogeneity with the values of the statistical parameter Q, I^2, and τ^2. The test's findings showed that the Q-statistical value was 242.499; thus, Q > df had a p-value of 0.0010, which is less than 0.05. Therefore, the meta-analysis sample data is diverse, and the heterogeneity of research study outcomes is influenced by sampling error and population diversity in impact sizes. Based on the value of parameter I 2 obtained at 86.137%, the same result was achieved to support the premise of considerable heterogeneity. The parameter 0.476 is therefore greater than zero. Additionally, it implies heterogeneity because the effect sizes linked to the outcomes of each study differed. A model with fixed effects is used if the data distribution is homogenous, and a model for random effects is used if the distribution is heterogeneous. The fact that this meta-analysis satisfied three of the criteria for heterogeneity indicates that each research study's executive summary displays a distinct effect magnitude. This research uses a random-effects model to calculate the size of each research and the overall influence based on data from forest plots.

Learning outcomes during the student mathematics learning process serve as dependent variables in this study. Independent factors are online and conventional learning models. Descriptive data on student learning outcomes during their math learning process are converted into measurements through effect size analysis. The statistical study of impact sizes generates organized statistics with numerical data based on observable variables and measures. Cohen's d or Hedges' g effects sizes were used when utilizing contrast groups, it is a relevant measurement that seeks to determine the effect sizes d and g by dividing the mean difference between each of the control and experimental groups by the sum of those groups' standard deviations. The effect size analysis of this study used SMD because the size of the study findings varied. For each sample in the meta-analysis research study, the effect size g was calculated using the adjustment factor of the random effects model. The results are displayed in Table 3.

Table 3 presents a study of the measure of the effect of SMD Hedges g on the outcomes of students' mathematical learning processes. In studies using meta-analysis, the significance rate for computational hedges g was 95%. Forty-one and weight of impact empirical research studies are shown in Table 3 with lower and upper limits at a significance level of 95%. The size of the impact is strong, small, medium, and high described as 0,00 – 0,20; 0,21 – 0,50; 0,51 – 1,00; and greater than 1,01. The designation of impact measures shows the value of applying online learning on student performance outcomes in the experimental class math learning process when compared to taking traditional classes The results showed that when compared to traditional learning, applying online learning improved the quality of the mathematics learning process in each study used in the meta-analysis, with each study providing the same results with a measure of beneficial impact. However, the categorization of each research study to the magnitude of the effect is unique.

Code	SMD	95%-CI	%W (random)	Code	SMD	95%-CI	%W (random)
A1	1.184	[0.51; 1.86]	2.308	A19	1.850	[1.43; 2.27]	2.683
A2	1.896	[0.93; 2.86]	1.853	A20	0.651	[0.12; 1.18]	2.532
A3	1.492	[0.93; 2.05]	2.487	A21	0.526	[0.04; 1.02]	2.588
A4	0.945	[0.33; 1.56]	2.396	A22	3.352	[2.64; 4.07]	2.237
A5	1.478	[0.92; 2.04]	2.488	A23	1.575	[0.87; 2.28]	2.248
A6	1.436	[0.93; 1.94]	2.563	A24	0.755	[0.23; 1.28]	2.539
A7	0.760	[0.26; 1.26]	2.575	A25	0.890	[0.31; 1.47]	2.460
A8	0.630	[0.10; 1.16]	2.534	A26	1.436	[0.93; 1.94]	2.563
A9	1.216	[0.71; 1.72]	2.571	A27	0.884	[0.41; 1.36]	2.608
A10a	2.397	[1.79; 3.00]	2.413	A28	0.669	[0.06; 1.28]	2.410
A10b	1.836	[1.28; 2.39]	2.498	A29	0.546	[0.05; 1.05]	2.576
A11	0.425	[-0.07; 0.92]	2.581	A30	1.861	[1.28; 2.44]	2.458
A12a	2.273	[1.62; 2.92]	2.344	A31	0.604	[0.34; 0.87]	2.874
A12b	0.873	[0.34; 1.40]	2.530	A32	1.330	[0.81; 1.85]	2.548
A13	3.549	[2.58; 4.52]	1.843	A33	0.825	[-0.01; 1.66]	2.051
A14	1.223	[0.67,1.77]	2.497	A34	0.957	[0.03; 1.88]	1.910
A15a	0.674	[0.19; 1.16]	2.591	A35	0.863	[0.28; 1.44]	2.454
A15b	0.609	[0.12; 1.10]	2.595	A36	1.506	[0.94; 2.07]	2.478
A16	0.059	[-0.45; 0.57]	2.566	A37	1.885	[1.22; 2.55]	2.317
A17	1.230	[0.66; 1.80]	2.467	A38	0.955	[0.45; 1.46]	2.561
A18	3.354	[2.62; 4.09]	2.203				

Table 3. Results of impact size estimation

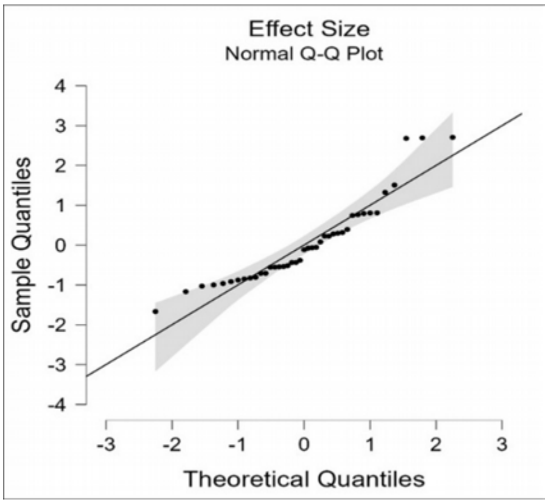

Figure 2. Shows the data plot's outcome based on the distribution of effect sizes

Size of the impact data is shown as a distribution plot in Figure 2 based on the sample from an investigation that was used for the meta-analysis. The effect size statistics of every research project show that the data are distributed with 95% confidence intervals around the y = x line. Various effect sizes must be dispersed around the y = x line and fall within the 95% confidence range for the data to be considered normally distributed, according to. This suggests a regularly distributed effect size distribution, with normal spacing between the two curved lines. To distinguish between variations in how well traditional learning and online learning impact the learning process of mathematics, the studies considered for this meta-analysis to be valid, integrated, and statistically noteworthy.

Analysis of online learning in the student's mathematics learning process is shown by forest plot analysis. For each meta-analysis outcome, a summary of the effect size analyses utilizing forest plots and standard errors is provided. The woodland plot serves as an example of a meta-conclusions analysis. The forest plot is characterized similarly to a forest assembled to build a forest for each research topic. For each research article, the Forest Plot displays lower and upper effect size boundaries as well as summary data on effect sizes with boundaries to the lower and upper derived from the random effects model claims. The forest plot displays weights for each impact size as well as summary effects. Figure 3 displays each meta-analysis study together with the effect sizes and standard errors obtained through the use of forest plot analysis and the JASP tool application.

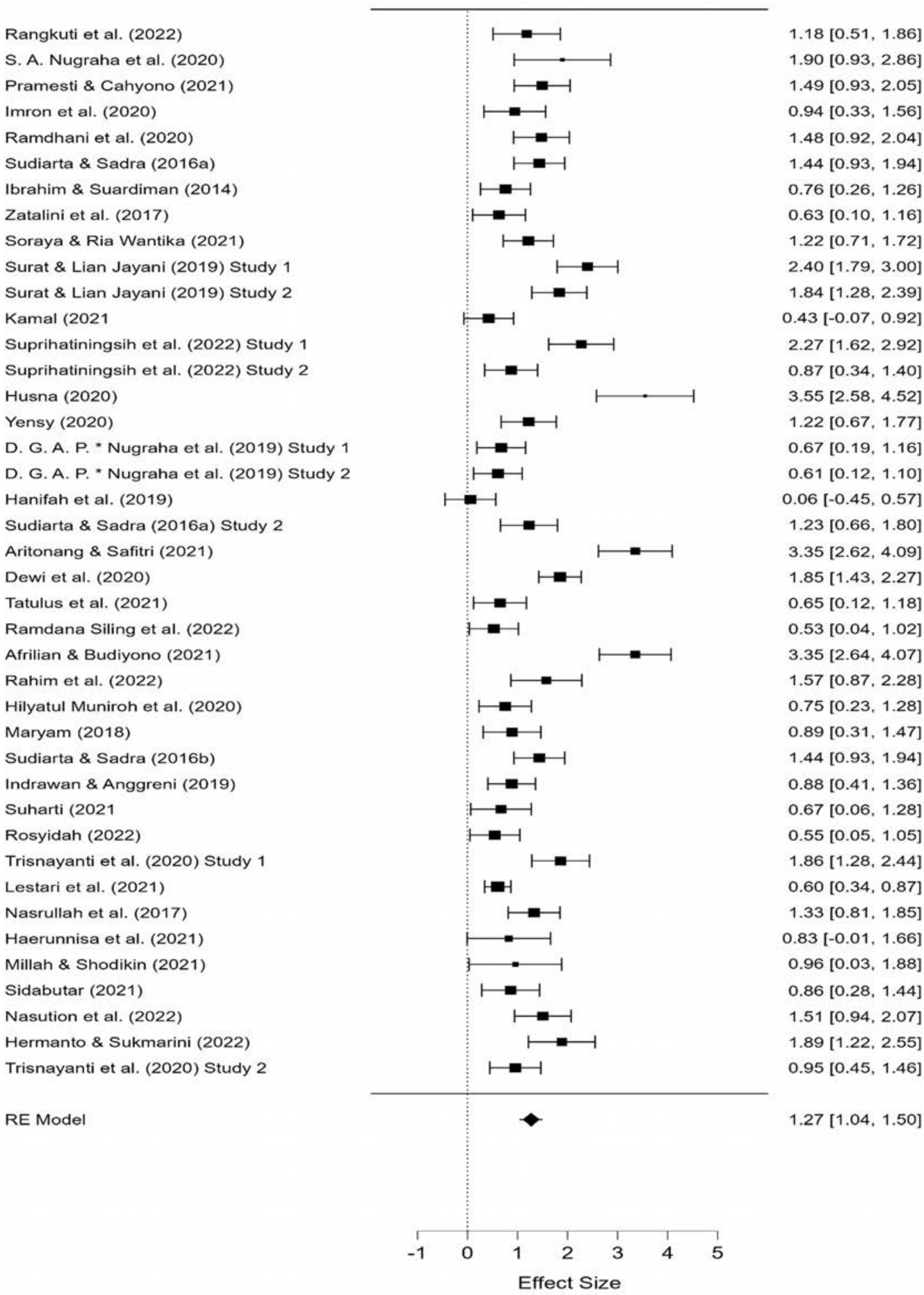

Figure 3. Results from a forest plot using random effects

The results of the random effects model-based forest plot analysis are shown in Figure 3. The impact of online learning is measured by the measure of effect. Online learning has been able to assist students in improving their learning outcomes because the size of the effect of each research study is greater than zero. In addition, Figure 3 shows that each sample from the research paper considered statistical significance found in the meta-analysis impact based on the size of the total effect. The suitability of the study is determined by a limiting confidence interval for each magnitude of the effect. If the confidence interval excludes 0, then the study is considered statistically noteworthy. Therefore, impact measures 41 studies have non-zero confidence intervals, which impacts the summary effect size.

3.2. Moderator Variables That Affect Students' Mathematics Learning In Online Learning

The outcomes from other forest plot analyses show that there are variations in the impact of online mathematics learning and conventional approaches to students' mathematics learning process by adding p-value estimates and estimated summary effect measures. The analysis findings for estimating Table 4 displays the estimated values.

Estimates of overall impact measures using randomized effect models are shown in Table 4. The p-value must be greater than 0.001 (p-value lower than 0.05) for the hypothesis test to produce a summary of a projection of the effect size result that is not zero. Moderator variables covering the level of education, the area of online learning research in Indonesia, the type of online learning, the impact of the output, and the number of samples show variations between online and conventional learning in the student's mathematics learning process. The estimated value of the summary effect is 1.268 [95%-CI:1.056; 1.479] $p < 0.001$ or $p < 0.05$, with an accuracy range of 95%. In addition, if the confidence interval includes 0, it is statistically significant. In forest plots according to research, online learning outperformed conventional mathematics learning by 126.8%. The results of the calculation of the value of the cumulative impact of online learning on the student's mathematics learning process on the moderator variable, especially at the education level, showed that the data for Primary School (PS) was 1,719 [95%-CI: 0.531; 2.907], $p < 0.001$ or $p < 0.05$.

This figure shows that learning in Primary School (PS) has the greatest impact when compared to JHS, SHS, and University colleges. Furthermore, the online learning research area in Indonesia that has the greatest influence is the North Sumatra region with 1,787 data [95%-CI: 0.325; 3,250]. Furthermore, online learning with mobile learning has the greatest impact, namely 2,186 data [95%-CI: 0.740; 3.633]. Online learning has the greatest impact on student learning motivation, namely 2,139 data [95%-CI: -0.209; 4,488]. In addition, sample sizes with criteria 1 to 30 and more than 30 students revealed variations in the impact of learning with traditional approaches and online. A sample size of more than 30 has a higher impact on online learning research in Indonesia. As a result, teaching using an online learning approach for classes of more than 30 students is more efficient than teaching classes of less than 30 students.

Publication bias occurs if the meta-analysis sample omits pertinent research studies (Retnawati et al., 2018). The various results give less information and have broader confidence ranges, but have no impact on the effect size. The study population might not accurately reflect the study population as a whole. (Borenstein et al., 2009). Finding study results that are statistically significant but do not support the theory's formulation can be referred to as discovering publication bias. Reviews show that learning is a process mathematics is further improved by using online learning than by traditional instruction. Because they use both learning strategies, 41 journals have published research articles utilizing descriptive data analysis. On the other hand, publication bias is found using the Fail-Safe N method.

The Trim and Fill approach is a detailed process procedure that excludes small sample size research that significantly affects the forest plot's favorable side and recalculates effect sizes for each iteration until the funnel plot is level. The distribution of impact size is represented by open or closed circles that form a funnel-like form in the funnel plot graph. Publications are identified visually by analyzing the effect size distribution internal or external to the funnel. The distribution of effect sizes on either side of a vertical line is equal, creating a symmetrical display of the total effect size. The impact of a study conducted outside of the funnel is distributed toward the top and middle. When the majority of research studies are concentrated toward the bottom of the graph or funnel along just one vertical axis, publication bias is present (Borenstein, Hedges & Rothstein, 2007). The random effects model for every sample in a meta-analysis in Figure 4 is based on effect sizes and standard errors.

Moderator variable	Study Code	Estimate	95%-CI	Standard error	p-value
School level					
Junior High School (JHS)	A1, A3, A6, A8, A11, A12a, A12b, A15a, A15b, A17, A20, A21, A24, A26, A27, A29, A34	0.954	[0.737; 1.172]	0.111	< 0.001
Primary School (PS)	A2, A4, A7, A22	1.719	[0.531; 2.907]	0.606	0.005
Senior High School (SHS)	A5, A9, A10a, A10b, A16, A18, A19, A23, A28, A30, A31, A33, A35, A36, A37, A38	1.417	[1.042; 1.793]	0.192	< 0.001
University college	A13, A14, A25, A32	1.660	[0.813; 2.506]	0.432	< 0.001
Types of online learning					
Online in network	A2, A22, A31, A34	1.691	[0.306; 3.076]	0.707	0.017
Blended learning	A3, A6, A15a, A15b, A17, A18, A20, A25, A26, A29, A30, A38	1.232	[0.860; 1.604]	0.190	0.001
E-learning	A7, A8, A9, A10a, A10b, A19	1.441	[0.910; 1.972]	0.271	0.001
Google Classroom	A11, A23, A35, A36	1.066	[0.510; 1.622]	0.284	0.001
Mobile learning	A12a, A12b, A13	2.186	[0.740; 3.633]	0.738	0.003
Whatsapp Group	A14, A21	0.863	[0.180; 1.546]	0.348	0.013
E-learning Edmodo	A16, A27, A28, A32	0.737	[0.205; 1.268]	0.271	0.007
Android-based smartphones	A33, A37	1.386	[0.349; 2.423]	0.529	0.009
Impact outcome					
Learning outcomes	A1, A2, A3, A4, A8, A9, A10a, A12a, A12b, A13, A14, A20, A21, A24, A27, A28, A33, A35, A37	1.250	[0.958; 1.543]	0.149	< 0.001
Learning achievement	A5, A7, A11, A23	1.027	[0.487; 1.568]	0.276	< 0.001
Mathematical problem solving	A6, A16, A26, A29, A31, A34, A36	0.920	[0.508; 1.331]	0.210	< 0.001
Concept understanding mathematics	A17, A30	1.544	[0.925; 2.163]	0.316	< 0.001
Motivation study	A22, A38	2.139	[-0.209; 4.488]	1.198	0.074
Indonesian territory					
North Sumatera	A1, A18, A35	1.787	[0.325; 3.250]	0.746	0.017
Central Java	A2, A11, A25	0.967	[0.253; 1.681]	0.364	0.008
East Java	A3, A9, A22, A29, A31, A34, A37	1.411	[0.766; 2.056]	0.329	< 0.001
West Nusa Tenggara	A4, A21, A33	0.713	[0.364; 1.061]	0.178	< 0.001
Bali	A5, A6, A10a, A10b, A15a, A15b, A17, A19, A26, A27, A30, A38	1.375	[1.071; 1.679]	0.155	< 0.001
South Sulawesi	A8, A28	0.647	[0.248; 1.045]	0.203	0.001
West Kalimantan	A12a, A12b	1.560	[0.189; 2.932]	0.700	0.026
Banten	A24, A32	1.044	[0.480; 1.608]	0.288	< 0.001
Sample size					
$1 \le N \le 30$		1.153	[0.859; 1.447]	0.150	< 0.001
$N > 30$		1.357	[1.057; 1.656]	0.153	< 0.001
Overall		1.268	[1.056; 1.479]	0.108	< 0.001

Table 4. Shows the results of the impact size estimation

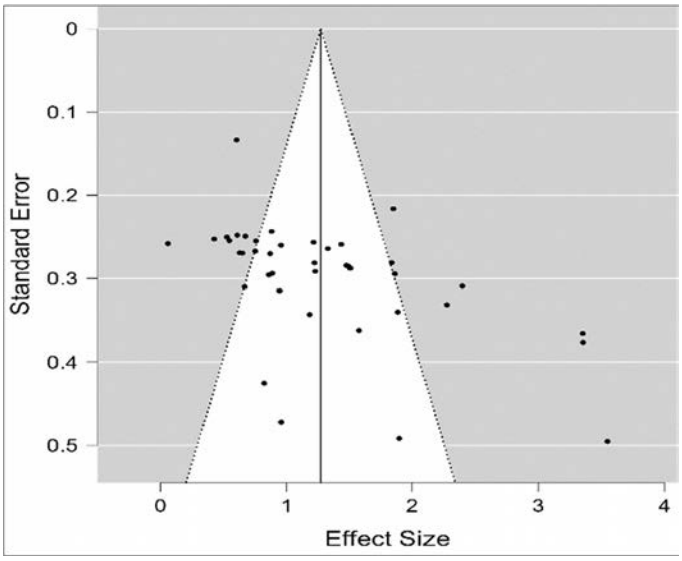

Figure 4. A funnel plot with models for the Trim and Fill

Dependent Variable	Rank Correlation Method		Regression Method	
	Correlation coefficient	**p-value**	**Regression Coefficient**	**p-value**
Mathematics learning process	0.426	< 0.001	3.942	< 0.001

Table 5. Using rank correlation and regression, the calculation analysis produced the following results

Figure 4 illustrates how the impact of online learning in Indonesia and the impact of traditional learning methodologies varies among a wide variety of studies. Figure 4's funnel plot results show that the vertical line is symmetrically covered by the effect sizes. The findings do not show publication bias, despite experiments outside the bottom and middle of the funnel being closed circles. It seems aesthetically subjective to use funnel plots to identify biased publications. Because of this, the results of funnel plots are not very accurate at identifying publication bias in meta-analytical investigations. In this work, statistical tests for the funnel plots were built using rank correlation, regression, and the Fail-Safe N technique. The regression, though technique seeks to investigate the straight-line correlation between the estimated intervention impact as well as the standard error, using rank correlation explores the link between the estimated sampling variance and the intervention impact (Begg & Mazumdar, 1994; Lin & Chu, 2018; Egger, Smith, Schneider & Minder, 1997). The findings of the computation study of the two methods utilizing the JASP application are displayed in Table 5.

As can be seen in Table 5, rank correlation and regression techniques were used to select a sample of meta-analyses used to evaluate publication bias in the impact of online learning models on students' math learning processes. For both strategies, the values are 0.426 and 3.942, with a p-value of less than 0.001. Based on the p-value, the asymmetry in the funnel plot graph shows that there is no publication bias. With the results of using the funnel plot, one can gauge the validity of the data from the meta-analysis. If the impact is greatest measure values in the funnel plot fall between two lines, and the data is distributed normally and reliably (Rosenberg, Adam & Jessica, 2000). The two pyramid-shaped lines in the funnel plot chart in Figure 4 illustrate this. Two sizes of effects are in the chart rather than in the line. So that the sample data for the meta-analysis is spread consistently and reliably. This suggests that reliable meta-analysis is used to compare the effectiveness of traditional education with online learning in enhancing the quality of students' mathematical learning processes and outcomes.

The Fail-Safe N approach was another publication identification technique employed in this investigation. A strategy for spotting publication bias in research is called Fail-Safe N (FSN) (Rosenthal, 1979). Let's say the FSN value exceeds 5k + 10. Mullen, Muellerleile and Bryant (2001), using a sample size of k, conducted a meta-analysis and found no evidence of publication bias. This FSN score also suggests how many more studies in the field were incorporated to mitigate publication bias if the meta-finding analysis warrants it. The following file drawer analysis using JASP yielded the value of N. (see Table 6).

Mullen et al. (2001), claim that the FSN value of 11356 specified from the analysis of the file drawer is greater than 5k+10=215, where k=41. These results suggest that the articles included in the studies use meta-analysis objectives. Therefore, there is no publication bias when comparing the effectiveness of traditional learning with online studying to enhance kids' mathematical abilities and learning processes and outcomes. Trim and Fill is a technique designed to determine how traditional learning and different online learning affect a student's mathematical learning process. Based on the results of the random effect model, this forest plot was used to examine the impact of the Trim and Fill model.

Dependent Variable	Fail-Safe N	Target Significance	Observed Significance
Mathematics learning process output.	11356	0.050	< 0.001

Table 6. Analysis of a file drawer results

4. Discussion

The meta-analytic study is a method for combining relevant research results in a particular field. In a meta-analysis, effect sizes are used to measure how much influence an intervention or risk factor has on the observed outcome. Common effect size categories include no effect, small effect, moderate effect, and large effect. In the given context, the analysis shows that there are different effect sizes for each level of schooling. The following is an explanation of why each effect category can occur:

- Small Effect: The Junior High School (JHS) study showed an effect size of 0.954 with a confidence interval between 0.737 and 1.172. Although the effect is significant (p-value < 0.001), the relatively small effect size indicates that the influence of the factors studied is not too strong at this level of education. Other factors may also play a role in influencing the observed results.
- Moderate Effect: The Primary School (PS) study showed an effect size of 1.719 with a confidence interval between 0.531 and 2.907. The p-value was 0.005, indicating a significant effect. Moderate effect sizes indicate that the factors studied have a significant influence on this level of education. Differences in the treatment or factors observed have a significant impact on the variables measured.
- Large Effect: The Senior High School (SHS) Study showed an effect size of 1.417 with a confidence interval between 1.042 and 1.793. The p-value <0.001 indicates a significant effect. The large effect size indicates that the factor under study has a strong influence on this level of education. The treatment or factors observed have a significant impact on the variable being measured.
- Large Effect: The University College study showed an effect size of 1.660 with a confidence interval between 0.813 and 2.506. The p-value <0.001 indicates a significant effect. The large effect size indicates that the factor under study has a strong influence on this level of education. The treatment or factors observed have a significant impact on the variable being measured.

Differences in effect sizes can be caused by a variety of factors, including the complexity of the material being taught, the level of cognitive maturity of students, the learning environment, and the teaching methods used. In addition, variations in student populations and differences in study designs can also influence the observed effect sizes.

In the moderator variable for types of online learning, each effect in the small, medium, and large categories can occur due to variations in the effect of each type of online learning on learning outcomes. The following explains why each effect can be categorized under different measures:

- Small Effect: Studies on Whatsapp Group (effect size 0.863) and E-learning Edmodo (effect size 0.737) show small effect sizes. Although the p-value indicates a significant effect, this relatively small effect size indicates that the use of Whatsapp Group and Edmodo E-learning has a limited effect on learning outcomes. Other factors such as teaching methods or level of application may have influenced the observed effect sizes.

- Moderate Effect: Studies on Online networks (effect size 1,691), Blended learning (effect size 1,232), E-learning (effect size 1,441), and Google Classroom (effect size 1,066) show moderate effect sizes. Although the effect is not very large, the use of this type of online learning has a significant effect on learning outcomes. Variations in study designs, usage characteristics, and other factors may account for differences in effect sizes between these types of online learning.

- Large Effect: The study on mobile learning (effect size 2.186) shows a large effect size. The use of mobile learning has a strong influence on learning outcomes. This effect can be due to the interactive nature, portability, or unique characteristics of learning via mobile devices. However, other factors such as the study design or the population studied can also play a role in influencing the observed effect size.

In analyzing effect sizes for moderating variables on learning outcomes, we look at several categories of effects that can occur:

- Small Effect: A study in Mathematical Problem Solving (effect size 0.920) shows a small effect size. Although the p-value indicates a significant effect, this relatively small effect size indicates that this moderator variable has a limited effect on students' ability to solve mathematical problems. Other factors such as learning methods or individual factors may also influence the observed effect sizes.

- Moderate Effect: Studies on Learning Outcomes (effect size 1.250), Learning Achievement (effect size 1.027), and Concept Understanding Mathematics (effect size 1.544) show moderate effect sizes. Although the effect is not very large, this moderator variable has a significant effect on learning outcomes. Variations in study design, types of learning interventions or approaches, and other factors may account for differences in effect sizes between the types of learning outcomes observed.

- Large Effect: The study on the Motivation Study (effect size 2.139) showed a large effect size. This moderator variable has a strong influence on student learning motivation. Although the p-value does not indicate a statistically significant effect ($p > 0.05$), the large effect size indicates the potential importance of motivation in influencing learning outcomes. Nonetheless, because the p-value is not significant, this finding needs to be interpreted with caution and may require further research to understand a clearer relationship between this moderator variable and student motivation.

In the analysis based on geographic area and sample size, it can be explained why each small, medium, and large effect occurs:

- Small Effect: When looking at data by geographic region, for example in studies A1, A18, and A35 in North Sumatra, we see an effect size of 1.787 with confidence intervals between 0.325 and 3.250. Even if the p-value indicates a significant effect, a sufficiently wide confidence interval indicates uncertainty in the estimate of the effect size. It is possible that there were variations in study design, data collection methods, or other factors that influenced the results may explain why the observed effect was relatively small. In addition, differences in sample size between studies in each geographic area can also affect effect size estimates.

- Moderate Effect: When looking at data by geographical area, such as in other regions such as Central Java, East Java, West Nusa Tenggara, Bali, South Sulawesi, West Kalimantan, and Banten, each region has a different estimated effect size and can be categorized under a certain effect size. Moderate effect sizes can occur when there is significant variation in study results across different regions. Factors such as differences in socio-cultural contexts, differences in curricula or learning approaches used, as well as other local factors can influence the observed effect sizes.

- Large Effect: Analysis by sample size showed that studies with a sample size of over 30 had a larger effect size (1,357) compared to studies with a sample size of 1 to 30 (1,153). A larger effect size in a study with a larger sample may indicate a stronger relationship between the variables studied. The larger the sample used in the study, the more accurate the effect size estimates obtained. With a larger sample size, we have a better tendency to generalize research results to a wider population

41 research articles were found in the literature review that, in terms of sampling size, average, and standard deviation, satisfied the criteria for a meta-analysis. Perform a descriptive analysis using the traditional educational model in the control class and the online learning model in the experimental class. For each research article, the advantages of online learning to enhance students' math learning process are statistically significant. Online and traditional learning have a consistent combined effect on students' mathematical learning processes. According to Cohen, Manion and Morrison (2007), the measure of the impact of online learning is 1,268 [95%-CI:1,056; 1,479]. The findings of this study and those of earlier studies conducted by Sudiarta and Sadra (2016) state that the understanding of mathematical concepts and the ability to solve problems of students who follow a blended learning-based learning model animated videos to help is better than understanding mathematical concepts and problem-solving skills of students who follow conventional learning. Therefore, blended learning-based learning models assisted by animated videos have a positive effect on students' problem-solving ability and understanding of mathematical concepts. This is supported by field findings that students who take part in blended learning-based learning assisted by animated videos are more active, have higher curiosity, are more motivated, and are passionate about learning mathematics compared to students who take part in conventional learning.

It was further explained that before carrying out blended learning systematically in their respective schools, it is necessary to make serious preparations including (a) increasing the capacity of online learning infrastructure by schools, (b) improving the ability of teachers to prepare online learning materials such as text, videos, animations and so on as the main material that students can learn online and which are oriented towards achieving learning objectives, and of course, with face-to-face learning as a continuation of online learning. (c) In addition, blended learning also needs to be a means of joint learning by teachers in a collegial manner, therefore it is highly recommended that the application of blended learning is combined with the principles of lesson study (Sudiarta & Sadra, 2016).

Surat (2018) asserts that e-learning and the Problem Based Learning approach have an impact on students' mathematical learning results and learning creativity. It is advised that problem-based learning, with the aid of e-learning, be used as an alternate learning model by math teachers in the classroom. According to the findings of research by Kamal (2021), students who are taught using Google Classroom with Powtoon learning media do better in their mathematics classes than students who are taught using Google Classroom with assignments. Score: 70 points more than 75% for the percentage of pupils taught utilizing Google Classroom and Powtoon learning materials. In the midst of the Covid-19 coronavirus pandemic or in other conditions requiring Distance Learning, the application of learning through Powtoon-based Google Classroom can be used as an alternative for teachers in improving student mathematics learning achievement. Powtoon learning media is easy to apply in the learning process and will give an interesting impression to students.

Learning that is carried out online is also evaluated for its effect on the mathematics education process utilizing moderator variables such as education levels, such as elementary, middle, and high school, and university. The estimated measurements of the summary effect of online studying student mathematics learning are for Primary School 1,719 [95%-CI: 0.531; 2.907], Junior High School 0.954 [95%-CI: 0.737; 1.172], Senior High School 1.417 [95%-CI: 1.042; 1.793], and University 1.660 [95%-CI: 0.813; 2.506]. It can be seen that online learning in elementary schools has the greatest influence on the process and results of learning mathematics for students. The results of this study show that learning with an online learning approach in large groups with more than 30 students is more powerful than learning with small groups of students (1-30). Another study showed that the collection of academic papers published in SINTA and GARUDA-indexed journals had a corresponding size of 1.04, higher than the grouping of articles from journals or proceedings indexed by Google Scholar (Ridwan et al., 2022).

Meta-analysis shows that online education has an effect on all levels of education, although it has a smaller impact than primary education. The picture of impact of online teaching in elementary schools, middle schools, and universities is very similar. Significant disparities between variables are also revealed by the online learning paradigm. Based on the findings of 41 research articles, a meta-analysis that assessed the efficiency of learning using online learning on students' math learning processes and outcomes also found publication bias. Trim and Fill rank correlation and regression are used to visually analyze funnel plot findings. Around the vertical lines, the effect sizes are distributed symmetrically, as seen in Figure 4. Although some studies have a closed circle outside the lower and middle pyramids, the findings do not indicate a publication bias. Due to the use of funnel plots to visually identify biased media, ratings seem subjective. As a result, the results of the funnel plot do not offer convincing proof of publication bias in meta-analytical investigations. As a result, Rank correlation, regression, and Fail-Safe N methods for funnel plots are used in this work to detect publication bias. With p larger than 0.05, the estimated correlation and regression coefficients were 0.426 and 3.942, respectively. The findings demonstrated that there was no publication bias when detecting publications using Rank correlation and regression techniques. The results of you can also use a funnel plot to evaluate the validity of meta-analytical data.

Graphs like Figure 4 show how a majority of effect size values are found between two lines with a pyramidal shape. The two effect sizes on the chart, however, are outside of this line. As a result, the meta-analysis sample data were trustworthy and normally distributed, according to (Rosenberg et al., 2000). When using the Fail-Safe N approach to find more studies, the meta-analysis sample lacks publication bias. Identify and validate the grouping of research findings on the effect of effective online teaching on the mathematics education of student process using a meta-analysis approach. The second contribution is the detection of utilizing the Trim and Fill approach, publication bias using a sample of research data from a meta-analysis. Based on previously published related study information, this meta-analysis method examines and evaluates the same challenges and ideas of conceptual análisis.

5. Implications of Findings for Future Research

The implications of the findings in the meta-analysis on the impact of online learning in mathematics learning can make valuable contributions to future research directions, mathematics teaching, and classroom practice. Here are some possible implications:

a) Exploration of online methods and strategies: The findings of the meta-analysis may provide insights into the most effective online learning methods and strategies in mathematics learning contexts. This may encourage further research to explore and develop innovative and evidence-based online learning methods.

b) Identify determinants of success: Meta-analyses can identify factors that contribute to successful online learning of mathematics. For example, findings may highlight the importance of social interaction, online tutor support, effective task design, or appropriate use of technology. This information can assist educators in designing more effective learning experiences in an online environment.

c) Curriculum adaptation considerations: In the context of online mathematics learning, meta-analyses can provide insights into how curricula can be adapted or tailored to support effective learning. These implications can assist in the development of relevant mathematics curricula, emphasizing the key aspects that students need to master in online learning environments.

d) Improving teachers' digital literacy: The findings of the meta-analysis can provide insights into the skills and knowledge required by teachers in teaching mathematics online. The implication is increased training and professional development for teachers in utilizing appropriate online learning technologies and strategies.

e) Evaluation and feedback management: Meta-analyses can provide information on the evaluation of online learning and the effective use of feedback in mathematics learning. The implication is that it is important to consider appropriate evaluation methods and provide constructive feedback in online learning environments.

In the context of this meta-analysis on the impact of online learning on mathematics learning, there are some general limitations to note: (1). Meta-analyses depend on the availability of data from relevant studies. If the number of relevant studies is limited or if there are limitations in access to primary data, this may affect the completeness and accuracy of the meta-analysis. (2). The studies included in the meta-analysis may have variations in research design, sample population, measurement methods, and other factors. This heterogeneity may affect the suitability of directly combining study findings and generating broader generalizations. (3). Published studies tend to have a tendency to report findings that are statistically significant or that have a positive effect. This may lead to publication bias, where studies with negative or non-significant findings are less likely to be published or reported in full. This bias may affect the results and interpretation of the meta-analysis. (4). Assessment of study quality in meta-analyses can be challenging. The various study quality assessment scales used in meta-analyses can have different approaches and criteria. Therefore, there is a potential for differences in assessment between different reviewers and careful assessment is needed to minimise assessment bias. (5). Although meta-analyses provide an overview of the findings of existing studies, interpretation of the results still requires consideration of context and the applicability of the results to specific populations. The results of the meta-analysis should be seen as a collaborative understanding of the findings, but further research is needed to gain a deeper understanding.

6. Conclusions

Based on the description above, several conclusions can be drawn that different effect sizes occur at each level of school education, namely Junior High School (JHS), Primary School (PS), Senior High School (SHS), and University College. Small effects occur in JHS, moderate effects occur in PS, while large effects occur in SHS and University College. This difference shows the different levels of influence of the factors studied at each level of education. Differences in effect sizes across types of online learning also occur. Small effects occur in Whatsapp Group and Edmodo E-learning, moderate effects occur in Online in-network, Blended learning, E-learning, and Google Classroom, while large effects occur in Mobile learning. This variation indicates that each type of online learning has a different effect on learning outcomes. In the moderator variable types of online learning, small, medium, and large effects occur due to variations in the effect of each type of online learning on learning outcomes. Teaching methods, level of application, and other factors can also influence the observed effect sizes.

In the learning outcome moderator variable, a small effect occurs in Mathematical Problem Solving, a moderate effect occurs in Learning Outcomes, Learning Achievement, and Concept Understanding Mathematics, while a large effect occurs in Motivation Study. This variation shows the different effects of the moderator variable on learning outcomes.

Differences in effect sizes by geographic region may be due to variations in study design, data collection methods, socio-cultural context, curricula, learning approaches, and other local factors. In addition, the effect size can also be affected by the number of samples used in the study. Studies with larger sample sizes tend to have larger effect sizes and more accurate estimates. Thus, the observed effect sizes can be more reliable and more representative of the relationship between the variables studied.

Variations in the impact of online learning and traditional learning methodologies in Indonesia in various studies. The funnel plot shows that the vertical line is symmetrically closed by the effect size, indicating that there is no indication of publication bias. However, there are few studies beyond the bottom and middle of the funnel, indicating the potential for unpublished publication.

7. Recommendations

Before carrying out online learning systematically in their respective schools, it is necessary to make serious preparations including (a) increasing the capacity of online learning infrastructure by schools, (b) improving the ability of teachers to prepare online learning materials such as text, videos, animations and so on as the main material that students can learn online and that is oriented towards achieving learning objectives, and of course related to learning in person as a continuation of its online education. (c) In addition, online learning also needs to be used as a means of joint learning by teachers in a collegial manner, therefore it is highly recommended if the application of blended learning is combined with the principles of lesson study.

The limitations of this study include the following: Limited sources of relevant and available data on the impact of online learning on the process of learning mathematics in Indonesia may affect the overall quality and strength of our findings. The studies used in meta-analyses may vary in terms of study design, sample population, measurement instruments, and variables studied. These differences can affect the ability to directly compare and combine findings from different studies.

Publication bias can be a problem in meta-analyses, especially if there is a tendency to publish or report research results that are statistically significant or that support a proposed hypothesis. This can lead to bias in the synthesis of findings and lead to an overestimation of the impact of online learning in meta-analyses. In research involving the impact of online learning in Indonesia, it is important to consider that Indonesia's social, cultural, and educational context can have significant differences from other countries. This difference can affect the way online learning is adopted and implemented, as well as its impact on the process of learning mathematics. The statistical methods used in meta-analyses have their own limitations and assumptions. For example, some methods may not be suitable for addressing study heterogeneity or may not accommodate variations in the quality of the studies involved

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

References

**Reference to the meta-analysis study*

*Afrilian, T.I., & Budiyono (2021). Pengaruh Media Online Quiz (Quizizz) Dan Non-Quiz Terhadap Motivasi Belajar Peserta Didik Pada Mata Pelajaran Matematika Selama Pembelajaran Daring Kelas 2 SD Muhammadiyah 14 Surabaya [The Effect of Online Quiz (Quizizz) and Non-Quiz Media on Students' Le]. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar [Journal of Primary School Teacher Education Research]*, 9(8), 3083-3092. Available at: https://ejournal.unesa.ac.id/index.php/jurnal-penelitian-pgsd/article/view/42232

Ali, W. (2020). Online and remote learning in higher education institutes: A necessity in light of COVID-19 pandemic. *Higher Education Studies*, 10(3), 16. https://doi.org/10.5539/hes.v10n3p16

*Aritonang, I., & Safitri, I. (2021). Pengaruh Blended Learning Terhadap Peningkatan Literasi Matematika Siswa [The Effect of Blended Learning on Improving Students' Mathematical Literacy]. *Jurnal Cendekia : Jurnal Pendidikan Matematika [Journal of Cendekia: Journal of Mathematics Education]*, 5(1), 735-743. https://doi.org/10.31004/cendekia.v5i1.555

Badeo, J.M., & Duque, D.A. (2022). the Effect of Socio-Scientific Issues (Ssi) in Teaching Science: a Meta-Analysis Study. *Journal of Technology and Science Education*, 12(2), 291-302. https://doi.org/10.3926/jotse.1340

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies*, 2(2), 113-115. https://doi.org/10.1002/hbe2.191

Begg, C.B., & Mazumdar, M. (1994). Operating Characteristics of a Rank Correlation Test for Publication Bias. *Biometrics*, 50(4), 1088. https://doi.org/10.2307/2533446

Borenstein, M., Hedges, L., & Rothstein, H. (2007). Meta-Analysis Fixed Effect vs. Random Effects. *Introduction to Meta-Analysis*. https://doi.org/10.1002/9780470743386

Borenstein, M., Hedges, L., & Rothstein, H. (2009). Introduction to Meta-Analysis. In *FMC Formacion Medica Continuada en Atencion Primaria*. Barat Sussex. https://doi.org/10.1016/S1134-2072(09)71285-X

Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J. et al. (2020). The psychological impact of the COVID-19 epidemic on college students in China. *Psychiatry Research*, 287(March), 112934. https://doi.org/10.1016/j.psychres.2020.112934

Carswell, A.D. (2002). Learner outcomes in an asynchronous distance education environment. *International Journal Human-Computer Studies*, 56, 475-494. https://doi.org/10.1006/ijhc.1004

Cohen, L., Manion, L., & Morrison, K. (2007). Research methods in education. In *Routledge Taylor & Francis Group* (6). https://doi.org/10.1134/S0021364007220055

Ćukušić, M., Alfirević, N., Granić, A., & Garača, Ž. (2010). e-Learning process management and the e-learning performance: Results of a European empirical study. *Computers and Education*, 55(2), 554-565. https://doi.org/10.1016/j.compedu.2010.02.017

*Dewi, K.A.I.D., Suarsana, I.M., & Juniantari, M. (2020). Pengaruh E-Learning Berbasis Rumah Belajar Terhadap Kemampuan Berpikir Kritis Matematika Siswa [The Effect of Home-Based E-Learning on Students' Critical Thinking Skills in Mathematics]. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembeljarannya [Wahana Maths and Science: A Journal of Mathematics, Science, and Their Learning]*, 14(1), 65-77.

Egger, M., Smith, G.D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *British Medical Journal*, 315(7109), 629-634. https://doi.org/10.1136/bmj.315.7109.629

Goodman, S.G., Seymour, T.L., & Anderson, B.R. (2016). Achieving the performance benefits of hands-on experience when using digital devices: A representational approach. *Computers in Human Behavior*, 59, 58-66. https://doi.org/10.1016/j.chb.2016.01.006

Güler, M., Bütüner, S.Ö., Danişman, Ş., & Gürsoy, K. (2022). A meta-analysis of the impact of mobile learning on mathematics achievement. *Education and Information Technologies*, 27(2), 1725-1745. https://doi.org/10.1007/s10639-021-10640-x

*Haerunnisa, N., Abdillah, Pramita, D., Mahsup, Mandailina, V., Syaharuddin et al. (2021). Efektivitas Pembelajaran Materi Program Linear Berbasis Aplikasi Desmos Terhadap Hasil Belajar Siswa [The Effectiveness of Learning Linear Program Material Based on Desmos Application on Student Learning Outcomes]. *Seminar Nasional Paedagoria [Paedagoria National Seminar]*, 1(September), 1-8. Available at: https://journal.ummat.ac.id/index.php/fkip/article/view/5611

Hak, T., van Rhee, H., & Suurmond, R. (2018). How to Interpret Results of Meta-Analysis. *SSRN Electronic Journal*, *March 2016*, 1-21. https://doi.org/10.2139/ssrn.3241367

Händel, M., Stephan, M., Gläser-Zikuda, M., Kopp, B., Bedenlier, S., & Ziegler, A. (2020). Digital readiness and its effects on higher education students' socio-emotional perceptions in the context of the COVID-19 pandemic. *Journal of Research on Technology in Education*, 54(2), 267-280. https://doi.org/10.1080/15391523.2020.1846147

*Hanifah, H., Supriadi, N., & Widyastuti, R. (2019). Pengaruh Model Pembelajaran E-learning Berbantuan Media Pembelajaran Edmodo Terhadap Kemampuan Pemecahan Masalah Matematis Peserta Didik [The Effect of E-learning Model Assisted by Edmodo Learning Media on Students' Mathematical Problem Solving Ability]. *NUMERICAL: Jurnal Matematika Dan Pendidikan Matematika*, 3(1), 31-42. https://doi.org/10.25217/numerical.v3i1.453

*Hermanto, H., & Sukmarini, M.A. (2022). Efektivitas Pembelajaran Matematika Tentang Trigonometri Melaluii Metode JIGSAW Berbantuan Media Pembelajaran Berbasis Android [The Effectiveness of Mathematics Learning In Trigonometry Lesson Using Jigsaw Method With Android Learning Media]. *Jurnal Kiprah Pendidikan [Journal of Education Gait]*, 1(2), 52-58. https://doi.org/10.33578/kpd.v1i2.28

*Hilyatul-Muniroh, S., Rojanah, S., & Raharjo, S. (2020). Efektivitas Pembelajaran Matematika Melalui Media Google Meet Ditinjau Dari Hasil Belajar Siswa Di Masa Pandemi Covid-19 [The Effectiveness of Mathematics Learning Through Google Meet Media in View of Student Learning Outcomes During the Covid-19 Pandemic]. *EDISI : Jurnal Edukasi Dan Sains [Journal of Education and Science]*, 2(2), 410-419. Available at: https://www.ejournal.stitpn.ac.id/index.php/edisi/article/view/1059

Hung, I.C., Yang, X.J., Fang, W.C., Hwang, G.J., & Chen, N.S. (2014). A context-aware video prompt approach to improving students' in-field reflection levels. *Computers and Education*, 70, 80-91. https://doi.org/10.1016/j.compedu.2013.08.007

Hunter, J., & Schmidt, F.L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings*. UK: Sage. https://doi.org/10.4135/9781412985031

*Husna, R. (2020). Efektivitas Pembelajaran Turunan Pada Masa Pandemi Covid-19 Melalui Media Mobile Learning Ditinjau Dari Hasil Belajar Mahasiswa. *Numeracy Journal*, 7(2), 324-333. https://doi.org/10.46244/numeracy.v7i2.1187

*Ibrahim, D.S., & Suardiman, S.P. (2014). Pengaruh Penggunaan E-Learning Terhadap Motivasi Dan Prestasi Belajar Matematika Siswa Sd Negeri Tahunan Yogyakarta [The Effects Of The Use Of E-Learning On The Learning Motivation Andachievement In Mathematics Of The Students Of SD Negeri Tahunan Yogyaka]. *Jurnal Prima Edukasia*, 2(1), 66-79. https://doi.org/10.21831/jpe.v2i1.2645

*Imron, Y., Affandi, L.H., & Turmuzi, M. (2020). Pengaruh Penggunaan Media Video Online Dalam Materi Pecahan Terhadap Hasil Belajar Matematika Siswa Kelas III SDN 15 Cakranegara Tahun Ajaran 2020/2021 [The Effect of Using Online Video Media in Fraction Materials on Mathematics Learning Outcomes of Third]. *Pendas: Primary Education Journal*, 1(2), 97-103. https://doi.org/10.29303/pendas.v1i2.58

*Indrawan, I.P.E., & Anggreni, N.L.P.Y. (2019). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Hasil [The Effect of Problem Based Learning Model on Learning Outcomes]. *Pinisi Journal PGSD*, 20(1), 326-338. https://doi.org/10.5281/zenodo.2662136

*Kamal, A.R. (2021). Implementasi Model Pembelajaran E-Learning Berbasis Powtoon Terhadap Prestasi Belajar Matematika Siswa [Implementation of Powtoon-Based E-Learning Learning Model towards Student Mathematics Learning Achievement]. *National Conference on Mathematics Education*, 2(1), 65-74. Available at: https://proceeding.unikal.ac.id/index.php/sandika/article/view/511

Kapasia, N., Paul, P., Roy, A., Saha, J., Zaveri, A., & Mallick, R. (2020). Impact of lockdown on learning status of undergraduate and postgraduate students during COVID-19 pandemic in West Bengal, India. *Children and Youth Services Review*, 116(105194). https://doi.org/10.1016/j.childyouth.2020.105194

Keengwe, J., & Bhargava, M. (2014). Mobile learning and integration of mobile technologies in education. *Education and Information Technologies*, 19(4), 737-746. https://doi.org/10.1007/s10639-013-9250-3

*Lestari, W., Pratama, L.D., & Sulistiowati, L. (2021). Efektifitas Pembelajaran Berbasis M-Pbl Dalam Menunjang Pembelajaran Matematika Secara Daring [Effectiveness of M-Pbl Based Learning in Supporting Online Learning of Mathematics]. *Jurnal Magister Pendidikan Matematika (Jumadika) [Journal of Master of Mathematics Education]*, 3(1), 35-44. https://doi.org/10.30598/jumadikavol3iss1year2021page35-44

Lin, L., & Chu, H. (2018). Quantifying Publication Bias in Meta-Analysis. *Biometrics*, 74(3), 785-794. https://doi.org/10.1111/biom.12817.Quantifying

Lipsey, M., & Wilson, D.B. (2001). *Practical meta-analysis.* Thousand Oaks, CA: Sage.

*Maryam, I. (2018). Pengaruh Blended Learning Berbantuan Microsoft Mathematic Terhadap Kemampuan Berpikir Kreatif [The Effect of Blended Learning Assisted by Microsoft Mathematic on Creative Thinking Ability]. *Jurnal Pendidikan Surya Edukasi (JPSE) [Journal of Education Surya Edukasi]*, 4(2), 23-34.

*Millah, S.N., & Shodikin, A. (2021). Analisis Efektivitas Pembelajaran Daring Dengan Pendekatan Kontekstual Terhadap Kemampuan Pemecahan Masalah Matematis [Analysis of the Effectiveness of Online Learning with Contextual Approach to Mathematical Problem Solving Ability]. *Unisda Journal of Mathematics and Computer Science (UJMC)*, 7(1), 25-31. https://doi.org/10.52166/ujmc.v7i1.2184

Mullen, B., Muellerleile, P., & Bryant, B. (2001). Cumulative meta-analysis: A consideration of indicators of sufficiency and stability. *Personality and Social Psychology Bulletin*, 27(11), 1450-1462. https://doi.org/10.1177/01461672012711006

*Nasrullah, A., Ende, E., & Suryadi, S. (2017). Efektivitas Penggunaan Media Edmodo Pada Pembelajaran Matematika Ekonomi Terhadap Komunikasi Matematika [Effectiveness of Using Edmodo Media in Economic Mathematics Learning on Mathematical Communication]. *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, 2(1), 1-10. https://doi.org/10.23969/symmetry.v2i1.346

*Nasution, A.P.A., Susilawati, E., & Wahyudi, M.D. (2022). Efektivitas Pembelajaran Daring Menggunakan Google Classroom Terhadap Kemampuan Pemecahan Masalah Matematika Siswa Pokok Bahasan Pertidaksamaan Linear Dua Variabel Di Kelas XI SMA Negeri 1 Tanjung Pura [The Effectiveness of Online Learning Using Google Cl]. *Jurnal Serunai Matematika [Serunai Journal of Mathematics]*, 14(2), 64-71. https://doi.org/10.37755/jsm.v14i2.694

*Nugraha, D.G.A.P., Astawa, I.W.P., & Ardana, I.M. (2019). Pengaruh model pembelajaran blended learning terhadap pemahaman konsep dan kelancaran prosedur matematis [The effect of blended learning model on concept understanding and mathematical procedure fluency]. *Jurnal Riset Pendidikan Matematika [Journal of Research in Mathematics Education]*, 6(1), 75-86. https://doi.org/10.21831/jrpm.v6i1.20074

*Nugraha, S.A., Sudiatmi, T., & Suswandari, M. (2020). Studi Pengaruh Daring Learning Terhadap Hasil Belajar Matematika Kelas IV [Study of the Effect of Online Learning on Grade IV Maths Learning Outcomes]. *Jurnal Inovasi Penelitian [Journal of Research Innovation]*, 1(3), 265-276. https://doi.org/10.47492/jip.v1i3.74

Owusu-Fordjour, C., Koomson, C.K., & Hanson, D. (2020). The impact of covid-19 on learning -the perspective of the ghanaian student. *European Journal of Education Studies*, 7(3). https://doi.org/10.5281/zenodo.3753586

Picardal, M.T., & Sanchez, J.M.P. (2022). Effectiveness of Contextualization in Science Instruction to Enhance Science Literacy in the Philippines: A Meta-Analysis. *International Journal of Learning, Teaching and Educational Research*, 21(1), 140-156. https://doi.org/10.26803/ijlter.21.1.9

*Pramesti, I., & Cahyono, H. (2021). Pengaruh Model Pembelajaran Blended Learning Terhadap Hasil Belajar Matematika Siswa Kelas VII SMP Negeri 3 Ngrambe Tahun Pembelajaran 2020/2021 [The Effect of Blended Learning Model on Mathematics Learning Outcomes of VII Grade Students of SMP Negeri 3 N]. *Indonesian Journal Of Education and Learning Mathematic (IJELM)*, 1(2), 40-44. Available at: https://ejournal.stkipmodernngawi.ac.id/index.php/IJELM/article/view/308

*Rahim, N., Bito, N., & Resmawan, R. (2022). Penggunaan Edpuzzle Berbantuan Google Classroom Terhadap Prestasi belajar Matematika Siswa SMK [The Use of Edpuzzle Assisted by Google Classroom on Mathematics Learning Achievement of Vocational School Students]. *JNPM (Jurnal Nasional Pendidikan Matematika) [National Journal of Mathematics Education]*, 6(3), 443-454.

*Ramdana-Siling, A., Sridana, N., Kurniati, N., & Sripatmi (2022). Pengaruh penerapan pembelajaran matematika realistik (PMR) berbantuan whatsapp terhadap hasil belajar matematika pada siswa kelas vii smp negeri 13 mataram tahun pelajaran 2021/2022 [The effect of the application of realistic mathematics learning (PMR) as]. *Griya Journal of Mathematics Education and Application*, 2(3), 773-783. https://doi.org/10.29303/griya.v2i3.220

*Ramdhani, T., Suharta, I.G.P., & Sudiarta, I.G.P. (2020). Pengaruh Model Pembelajaran Hybrid Learning Berbantuan Schoology Terhadap Prestasi Belajar Matematika Siswa Kelas XI IPS SMAN 2 Singaraja [The Effect of Hybrid Learning Model Assisted by Schoology on Mathematics Learning Achievement of Students of Grade X]. *Jurnal Pendidikan Matematika Undiksha [Undiksha Journal of Mathematics Education]*, 11(2), 62-68.

*Rangkuti, R.K., Sormin, M.A., & Sahara, N. (2022). Pengaruh Pembelajaran Online Terhadap Hasil Belajar Matematika Siswa di SMP Negeri Panyabungan [The Effect of Online Learning on Student Mathematics Learning Outcomes at SMP Negeri Panyabungan]. *EKSAKTA: Jurnal Penelitian Dan Pembelajaran MIPA [Journal of Research and Learning in Mathematics and Natural Sciences]*, 7(1), 77-86. https://doi.org/10.31604/eksakta.v7i1.77-86

Retnawati, H., Apino, E., Kartianom, Djidu, H., & Anazifa, R.D. (2018). Pengantar Meta Analisis. In *Pengantar Analisis Meta*. Parama Publishing.

Ridwan, M.R., Hadi, S., & Jailani, J. (2022). A meta-analysis study on the effectiveness of a cooperative learning model on vocational high school students' mathematics learning outcomes. *Participatory Educational Research*, 9(4), 396-421. https://doi.org/10.17275/per.22.97.9.4

Rosenberg, M.S., Adam, D.C., & Jessica, G. (2000). *Metawin Statistical Software for Meta-analysis. Version 2.0*, 137.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological Bulletin*, 86(3), 638-641. https://doi.org/10.1037/0033-2909.86.3.638

Rosenthal, R. (1991). Meta-Analytic Procedures for Social Research. In *Meta-Analytic Procedures for Social Research*. Newbury Park, CA: Sage Publications. https://doi.org/10.4135/9781412984997

*Rosyidah, M. (2022). Pengaruh Model Blended Learning Terhadap Kemampuan Pemecahan Masalah Kontekstual Materi Sistem Persamaan Linier Dua Variabel [The Effect of Blended Learning Model on Contextual Problem Solving Ability of Two-Variable Linear Equation System Material]. *Jurnal Pendidikan Guru Matematika [Journal of Maths Teacher Education]*, 2(3), 203-211. https://doi.org/10.33387/jpgm.v2i3.4990

*Sidabutar, R. (2021). Efektivitas Penerapan Media Pembelajaran Interaktif Berbasis Google Classroom Dalam Menyongsong Era Revolusi Industri 4.0 Terhadap Hasil Belajar Matematika Siswa [The Effectiveness of the Application of Interactive Learning Media Based on Google Classroom]. *Jurnal Ilmiah Aquinas [Aquinas Scientific Journal]*, 4(2), 344-352. https://doi.org/10.54367/aquinas.v4i2.1308

*Soraya, F., & Ria-Wantika, R. (2021). Pengaruh Pendekatan Realistic Mathematic Education Secara E-Learning Terhadap Hasil Belajar Matematika [The Effect of E-Learning Realistic Mathematic Education Approach on Mathematics Learning Outcomes]. *Buana Matematika : Jurnal Ilmiah Matematika Dan Pendidikan Matematika [Scientific Journal of Mathematics and Mathematics Education]*, 11(2), 151-164. https://doi.org/10.36456/buanamatematika.v11i2.3721

*Sudiarta, I.G.P., & Sadra, I.W. (2016). Pengaruh model blended learning berbantuan video animasi terhadap kemampuan pemecahan masalah dan pemahaman konsep siswa [The effect of animated video-assisted blended learning models on students' problem-solving and concept understanding skills]. *Jurnal Pendidikan Dan Pengajaran [Journal of Education and Teaching]*, 49(2), 48-58. https://doi.org/10.23887/jppundiksha.v49i2.9009

*Suharti, S. (2021). Efektivitas Penerapan Media Pembelajaran Interaktif Berbasis Edmodo dalam Menyongsong Era Revolusi Industri 4.0 terhadap Hasil Belajar Matematika Siswa [The Effectiveness of Edmodo-Based Interactive Learning Media Implementation in Welcoming the Era of In]. *Jurnal Cendekia : Jurnal Pendidikan Matematika [Journal of Cendekia: Journal of Mathematics Education]*, 5(2), 1025-1038. https://doi.org/10.31004/cendekia.v5i2.564

Sung, Y.T., Chang, K.E., & Liu, T.C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers and Education*, 94, 252-275. https://doi.org/10.1016/j.compedu.2015.11.008

*Suprihatiningsih, S., Harmini, T., Sudibyo, N.A., & Annurwanda, P. (2022). Eksperimentasi Pembelajaran Matematika Menggunakan Mobile Learning Dengan Pendekatan Differentiated Instruction [A Mathematics Learning Experiment Using Mobile Learning with Differentiated Instruction Approach]. *Riemann: Research of Mathematics and Mathematics Education*, 4(2), 34-42. https://doi.org/10.38114/riemann.v4i1.194

Surat, I.M. (2018). Peranan Model Pembelajaran Berbasis Etnomatematika sebagai Inovasi Pembelajaran dalam Meningkatkan Literasi Matematika. *Emasains: Jurnal Edukasi Matematika Dan Sains*, 7(2), 143-154. https://doi.org/10.5281/zenodo.2548083

*Surat, I.M., & Lian-Jayani, N.L. (2019). Pengaruh Model Pembelajaran Problem Based Learning Berbantuan E-Learning terhadap Kreativitas dan Hasil Belajar Matematika [The Effect of Problem Based Learning Model Assisted by E-Learning on Creativity and Learning Outcomes in Mathematics]. *Jurnal Emasains: Jurnal Edukasi Matematika Dan Sains [Journal of Maths and Science Education]*, *VII*(2), 205-213. https://doi.org/10.5281/zenodo.3552028

Talan, T. (2020). The effect of mobile learning on learning performance: A meta-analysis study. *Educational Sciences: Theory and Practice*, 20(1), 79-103. https://doi.org/10.12738/jestp.2020.1.006

*Tatulus, W., Sulangi, V.R., & Salajang, S.M. (2021). Pengaruh Pembelajaran Blended Learning Menggunakan Media Pembelajaran Edmodo Terhadap Hasil Belajar Siswa SMP [The Effect of Blended Learning Using Edmodo Learning Media on Junior High School Student Learning Outcomes]. *Jurnal Pendidikan Matematika Unpatti*, 2(3), 70-75. https://doi.org/10.30598/jpmunpatti.v2.i3.p70-75

Tezer, M., & Çimşir, B.T. (2018). The impact of using mobile-supported learning management systems in teaching web design on the academic success of students and their opinions on the course. *Interactive Learning Environments*, 26(3), 402-410. https://doi.org/10.1080/10494820.2017.1337037

Tezer, M., Yildiz, E.P., Bozkurt, S., & Tangul, H. (2019). The influence of online mathematics learning on prospective teachers mathematics achievement: The role of independent and collaborative learning. *World Journal on Educational Technology: Current Issues*, 11(4), 257-265. https://doi.org/10.18844/wjet.v11i4.4361

Tingir, S., Cavlazoglu, B., Caliskan, O., Koklu, O., & Intepe-Tingir, S. (2017). Effects of mobile devices on K-12 students' achievement: a meta-analysis. *Journal of Computer Assisted Learning*, 33(4), 355-369. https://doi.org/10.1111/jcal.12184

*Trisnayanti, N.P.E., Sariyasa, & Suweken, G. (2020). Pengaruh Model Pembelajaran Blended Learning Terhadap Pemahaman Konsep Dan Motivasi Belajar Siswa [The Effect of Blended Learning Model on Students' Concept Understanding and Learning Motivation]. *Jurnal MathEdu [Mathematic Education Journal]*, 3(3), 1-8. https://journal.ipts.ac.id/index.php/MathEdu/article/view/1920

*Yensy, N.A. (2020). Efektifitas Pembelajaran Statistika Matematika melalui Media Whatsapp Group Ditinjau dari Hasil Belajar Mahasiswa (Masa Pandemik Covid 19) [Effectiveness of Learning Mathematical Statistics through Whatsapp Group Media in View of Student Learning Outcomes]. *Jurnal Pendidikan Matematika Raflesia [Raflesia Journal of Mathematics Education]*, 05(02), 65-74.

*Zatalini, N.F., Minggi, I., & Rusli, R. (2017). Pengaruh Strategi Pembelajaran Flipped Classroom Menggunakan e-Learning Kelase Terhadap Hasil Belajar Matematika Siswa [The Effect of Flipped Classroom Learning Strategy Using e-Learning Kelase on Students' Mathematics Learning Outcomes]. *Issues in Mathematics Education (IMED)*, 1(2), 107-114.

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