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Meta-analysis of the effectiveness of ethnomathematics-based learning on student mathematical communication in Indonesia

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ABSTRACT

This meta-analysis aims to determine the effect of ethnomathematics learning on students' mathematical communication skills. Data from 28 research studies, including sample size, standard deviation, mean for both experimental and control groups, and other information, were collected using descriptive analysis. Data analysis techniques used meta-analysis on forest plots, with analytical techniques including heterogeneity testing, calculation of effect sizes, calculation of summary effects using random effects models, and identification of publication bias. The results showed that ethnomathematics-based learning improves students' mathematical communication skills. The effectiveness of ethnomathematical and conventional learning on students' mathematical communication skills is combined reliably. The effect size of ethnomathematical learning was 0.97 (95%-CI: 0.74; 1.20). Ethnomathematics-based learning is more effective when compared to traditional.

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1. INTRODUCTION

One of the key objectives of math instruction in elementary schools is to improve students' mathematical communication abilities because comprehension is thought to be primarily based on communication [1], [2]. One of the skills that students require is the ability to communicate mathematically. As they think, discuss, and make judgments, students can use their skills to grasp mathematics [3]. These skills can help students present mathematical concepts in diverse methods [4]. To promote students' thinking abilities and facilitate the sharing of ideas, mathematical communication skills should be a top priority in mathematics education.

The capacity to communicate mathematical concepts orally, in writing, and visually using images, graphs and other visual representations is a component of mathematical communication skills [5]. Verbal and written mathematical communication are crucial in enhancing students' comprehension of mathematical concepts. When students engage in discussions about mathematical ideas, explain their thought processes, and articulate their reasoning in written form, they deepen their understanding of the subject matter. Verbal communication allows students to express their thoughts, ask questions, and engage in meaningful conversations with peers and teachers [6]. Students may have the chance to exchange ideas through the mathematical communication method [7]. As a result, the solution must incorporate mathematical communication. It is possible to define mathematical communication as the capacity to convey mathematical concepts and symbols either vocally or in writing, images, or diagrams, based on the several definitions that have already been presented.

Contends that effective communication skills are crucial in classroom discussions as students must be able to state and explain, depict, listen, and ask questions to comprehend mathematics thoroughly. To put it briefly, communication is regarded as a means of expressing ideas, emotions, and feelings to others. Science literacy, self-efficacy, and reading comprehension have all shown how crucial it is for students to build their mathematical communication skills [8]–[12]. However according to recent research, teachers rarely provide students with training in mathematical communication, hence students' abilities to communicate mathematically are typically subpar [13], [14]. Additionally, insufficient mathematical expertise and metacognitive abilities are other factors that frequently contribute to students' difficulty in mathematical problem-solving and communication [15]–[17] claim that metacognition is an advanced level of cognitive activity that entails an individual actively controlling cognitive processes to comprehend and manage their learning. According to Chatzipanteli *et al.* [18], students who use their metacognitive skills may identify problems, rectify them, and determine the best method to apply what they have learned. This supports student success. To effectively increase students' ability to solve mathematical problems and communicate with others, teachers must use effective teaching techniques.

Although research on ethnomathematics has been widely carried out, there is little empirical evidence reporting the impact of ethnomathematics-based learning more broadly in Indonesia. Some studies concentrate on ethnomathematics or cultural contextualization. Three categories can be used to categorize the ethnomathematics research that has already been done. The first one includes research on how math is used in various cultures. The creation of cultural, craft, and fashion sites in Indonesia and the Philippines involved the use of ethnomathematical concepts for estimating, measuring, and patterning [19]–[21]. Studies that fall within the second category include looking at how ethnomathematics is used in mathematics education. These studies have been done, for example, in Hawai [22], Israel [23], and Indonesia [24], particularly in the teaching of geometry [25]–[28]. The third study category emphasizes how adept teachers are at imparting mathematics through the use of ethnomathematics, such as in Indonesia and Papua New Guinea [29]. The effect of learning based on ethnomathematics on mathematical communication abilities has not been disclosed by these investigations, Therefore, this meta-analysis research will reveal more broadly the impact of ethnomathematics-based learning, especially in Indonesia, on mathematical communication skills.

This study seeks to close this gap by investigating the broader effects of ethnomathematics-based education, particularly in Indonesia, and doing so by responding to three research questions. First, how has ethnomathematical learning impacted Indonesian students in elementary, middle, and higher education? To raise kids' math test performance, it is anticipated that this inquiry will encourage school stakeholders in Indonesia to take into account a novel strategy called ethnomathematics. Second, why and how does it affect students' ability to communicate mathematically when professors use an ethnomathematical approach? This inquiry will help math teachers understand what to teach and how to teach it by recognizing students' learning preferences and infusing popular culture media into students' daily lives. Third, how may ethnomathematics be incorporated into the mathematics curriculum? Fusing the ethnomathematics curriculum with this query seeks to enhance Indonesia's National Curriculum for mathematics. From the description, the problems answered in this study are: i) How effective is the application of ethnomathematics-based learning models to students' mathematical communication skills? (RQ1); ii) How is the effect of applying ethnomathematics-based learning models on students' mathematical communication skills? (RQ 2); and iii) How is the publication biased on the application of ethnomathematics-based learning models to students' mathematical communication skills? (RQ 3).

To determine the effectiveness and bias of publications on the application of ethnomathematics-based learning models to students' mathematical communication skills, there were several steps carried out. First, collecting research data based on independent variables, such as traditional learning models used by control groups and ethnomathematics-based learning models used by experimental groups. Second, information obtained using literature reviews, which include studies that using traditional learning models in control classes and ethnomathematics-based learning models in experimental classes. Third, comparing the effect of ethnomathematics-based learning success on the results of students' mathematical communication skills.

2. RESEARCH METHOD

This research 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 [30]. The meta-analysis compared the effects of teaching with an ethnomathematics approach on students' mathematical communication abilities. Related articles are searched through SINTA and GARUDA-indexed journals using Google Scholar.

2.1. Research procedures

The terms ethnomathematics and mathematical communication were used to search Google Scholar, SINTA, and the GARUDA site for works about ethnomathematics-based learning on students' mathematical communication skills. The next step is to gather research data based on independent variables, such as the traditional learning model used by the control group and the ethnomathematical-based learning model used by the experimental group. The outcome of pupils' mathematical communication abilities is the dependent variable. The research studies that satisfy the requirements are then identified from the search results once more. Identification is done by what kind of study that uses research using quasi-experiments and findings of descriptive data analysis are available, such as sample size, mean for both, and standard deviation experimental and control learning. The process for discovering relevant literature research using these criteria is shown in Figure 1. The flowchart was modified from Ridwan *et al.* [31].

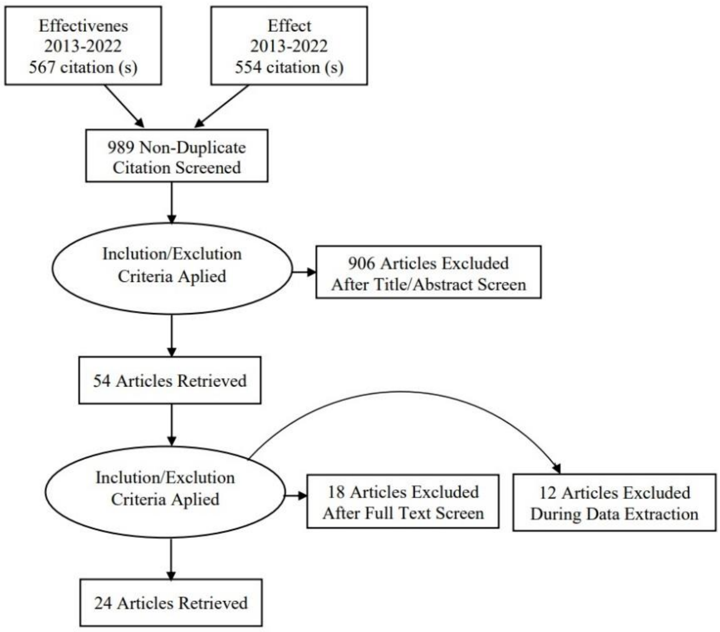

Figure 1. The study literature search flowchart

2.2. Data collection

Information was acquired using a review of the literature, which included studies utilizing a traditional learning model in the control class and an ethnomathematics-based learning model in the experimental class. While the study's dependent variable is the results of students' mathematical communication skills tests. Another criterion is research studies indexed by Google Scholar, GARUDA, and SINTA from 2013-2022. Based on an evaluation of the descriptive application of two educational groups to students' mathematical communication skills, the study criteria's findings were grouped and then coded. This is the difference in the measured variable between the experimental and control groups. To assess students' mathematical communication skills, descriptive analysis was used to identify the two learning models' mean and standard deviation, as well as the sample size. Use the Google Scholar search engine to look up articles in the indexed journals SINTA and GARUDA. There were 24 research studies from SINTA-recognized publications found in the literature search. While some studies simply employed Google Scholar-indexed journals, certain studies used SINTA and GARUDA-indexed journals. Of the 24 articles that were collected, there were four articles consisting of two studies and one article containing three studies, bringing the total study to 28 literature studies. Following that, the results of using the sample size, standard deviation, and mean, descriptive data analysis based on learning in the experimental and control groups were coded.

2.3. Data analysis

To uncover and generalize the results of earlier investigations, this work combines meta-analysis with forest plot analysis. The study compares the effects of successful ethnomathematical-based learning on the outcomes of students' mathematical communication skills. Both groups were recognized, and the effectiveness of their learning was evaluated. The forest plot approach is used to generate the based on the impact size of each meta-analysis sample and summary effect values. The dependent variable's learning effectiveness can be calculated by adding the summary effect size estimate, the z estimate, and the p-value. Reject the idea that the two learning models' efficacy varies if the estimated z value is less than 0.05 and the anticipated summary effect size is 0. The heterogeneity test was carried out before the forest plot analysis. The heterogeneity test determined whether the meta-analysis used a random or fixed effects model. Testing for heterogeneity can use Q, τ^2, or I^2.

3. RESULTS AND DISCUSSION

3.1. Results

There were 28 research papers found in the literature search, and the research sample criteria used in this meta-analysis were a quasi-experimental study, the use of learning with ethnomathematical experimental class models, and the use of the control class' traditional models. Based on the implementation of two lessons and descriptive data analysis of test results for mathematical communication abilities, the following criteria are available: sample size, mean, and standard deviation. The meta-analysis is based on the descriptive data analysis from each study and assesses the efficacy and validity of the ethnomathematics-based learning model on the student's performance in the mathematical communication ability test. Coding data from research papers, heterogeneity tests, effect size calculations, forest plot analyses, and publication bias detection are all steps in the meta-analysis process. Research study data coding as an initial step seeks to categorize the data's features in evaluating impact sizes. The following phase involved a diverse evaluation of the data sample that satisfied the criteria for creating the effect model used in the meta-analysis. Effect size and the impact of applying an ethnomathematics-based learning model on the outcomes of students' mathematical communication skills exams are provided by the computation of the impact size for each research study.

3.2. Data coding

Utilizing numerical data from descriptive data analysis of students' test results for mathematical communication abilities in Indonesia, the meta-analysis grouping of research findings was established. The results of the descriptive data analysis were produced using the standard learning model for the control group and the ethnomathematics-based learning model for the experimental group. Based on which research studies met the inclusion requirements, the data are categorized in this study's preliminary analysis. The meta-analysis comprised descriptive analyses of both groups and took into account the sample size, standard deviation, and mean of each study. The coding findings from the numerous research projects are summarized in Table 1.

Table 1 provides a summary of the findings from the coding of the research data. It is the outcome of descriptive data analysis of student test scores on mathematical communication skills using two different learning models. While the control group took part in traditional learning, the experimental group learned together based on ethnomathematics. Two research had different averages from the average of other studies, according to the results of group studies based on literature studies [32], [33].

3.3. Heterogeneity test

Heterogeneity in the meta-analysis approach is related to faulty sampling or variations in findings among different researches. To identify the cause of the disparity in study effect sizes, a moderator analysis was conducted [34]. To ascertain how much sampling error, population variance, and sizes in the study have an impact on the findings of each research study, tests for heterogeneity must be run. The outcome of the heterogeneity test also determines whether the study uses a fixed effect model or a random 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).

According to the findings of the mathematical communication ability test, Table 2 shows the outcomes of analyzing the research papers' heterogeneity using the statistical parameter values Q, I^2, and τ^2. The test's findings showed that the Q-statistical value was 66.608; 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 80.29%, the same result was achieved to support the premise of considerable heterogeneity. The parameter 0.3072 is therefore greater than zero. Additionally, it implies heterogeneity because the effect sizes linked to the outcomes of each study differed.

Table 1. Data coding results

Code	Researcher and research year	Experiment group			Control group		
		Ne	Xe	SDe	Nc	Xc	SDc
AR1	Umaedi Heryan_2018	30	74.8	7.94	30	70.43	7.33
AR2	Dianne Amor K_2019 (Studies 1)	30	59.37	17.49	30	45.57	14.97
AR3	Dianne Amor K_2019 (Studies 2)	30	28.5	6.16	30	29.33	7.58
AR4	I. Fujiati, Z. Mastur_2014	30	84.2	7.31	30	79.6	5.99
AR5	Nur Atikah, et al._2020 (Studies 1)	24	78.42	15.19	24	59.13	18.32
AR6	Nur Atikah, et al._2020 (Studies 2)	24	38.46	13.74	24	35	15,47
AR7	Dwi Ayu Safitri1_2021	31	40.65	12.81	30	42.89	11.57
AR8	Ayu Kartika N_2021 (Studies 1)	7	87.91	5.33	8	74.88	8.85
AR9	Ayu Kartika N_2021 (Studies 2)	25	84.15	6.43	20	74.14	7.15
AR10	Ayu Kartika N_2021 (Studies 3)	4	80.5	9.75	8	70	8.69
AR11	Muslimahayati_2019	32	74.48	12.26	32	60.21	14.74
AR12	Lukky Fadillah_2019	20	79.6	10.02	20	61.7	26.23
AR13	Yunita Aditya, et al._2022	31	81.16	11.66	31	69.5	16
AR14	Eko Pujianto_2016 (Studies 1)	36	81.66	17.8	37	59.73	18.78
AR15	Eko Pujianto_2016 (Studies 2)	36	68.61	10.25	37	59.73	18.78
AR16	Suci Nooryanti, et al._2020	40	82.35	6.79	34	77.12	5.8
AR17	Dwi Yanti, et.al_2018 (Studies 1)	33	83.09	6.92	31	65.42	9.87
AR18	Dwi Yanti, et.al_2018 (Studies 2)	33	50.27	10.25	31	34.84	12.37
AR19	Priya Dasini_2021	48	81.6	25.11	48	53.2	22.64
AR20	Resa Yulia P, et al._2017	29	70	10.05	29	65	11.4
AR21	Maria Agustina K, et al._2017	66	34.58	5.35	57	25.63	3.77
AR22	I Wayan Sumandya_2019	36	74.61	10.9	36	62.61	11.82
AR23	Fadilah, Rizki Amalia_2018	30	82.53	18.55	35	64.97	14.12
AR24	H. Farda, et al._2017	34	83.06	10.82	33	78.64	13.3
AR25	Kaselin, et al._2013	27	7.67	0.72	29	6.71	0.77
AR26	Laely Farokhah_2017	38	0.53	0.26	38	0.38	0.21
AR27	Erentiana P. S, et al._2021	30	59.67	15.13	30	61.33	13.89
AR28	Atika Erlina N._2019	36	44.68	6.69	36	36	6.61

Note: N=Sample size; X=Mean; S=Standard deviation

Table 2. The heterogeneity test analysis results in

Dependent variable	Test for heterogeneity parameter				
	Q-statistic			I^2	τ^2
	Value	*df*	*p*-value		
Mathematical communication skills	66.608	28	0.0010	80.29 %	0.307

3.4. Analysis of effect size calculation

The results of the student's mathematical communication skills exam serve as the dependent variable in this study. The independent factor is an ethnomathematical and conventional-based learning model. The descriptive data of the students' test results for their ability to communicate mathematically were converted into a measurement via the effect size analysis. Cohen's d or Hedges' g effects sizes were used when utilizing contrast groups [35]. It is a relevant measurement that seeks to determine the effect sizes d and g by dividing the mean difference between each experimental group and control group by the sum of those groups' standard deviations. The effect size analysis of this study used standardized mean difference (SMD) because the size of the study findings varied. The results are displayed in Table 3.

Table 3 displays the study of the SMD Hedges g effect size on the outcomes of the exam of students' mathematical communication abilities. In studies using meta-analysis, the significance level for computing Hedges g was 95%. The 28 empirical research studies' impact sizes and weights are displayed in Table 3 with lower and upper bounds at the 95% significance level. Strong, small, medium, and high impact sizes are described as 0.00-0.20; 0.21-0.50; 0.51-1.00; and greater than 1.01. The designation of impact sizes shows the value of applying ethnomathematics-based learning about the outcomes of students' performance in the experimental class mathematical communication abilities when compared to traditional taking classes under authority. Results showed that when compared to traditional learning, applying ethnomathematical-based learning improved students' mathematical communication skills in each of the studies used in the meta-analysis, with each study delivering the same outcomes with a favorable impact size. Each research study's categorization for effect magnitude, however, is unique. Some experts [32], [36], [37] all have research papers with impact sizes that fall into the weak effect size category: -0.119 (95% CI: -0.625; 0.388), 0.181 (95% CI: 0.684; 0.322), and -0.113 (95% CI: -0.619; 0.394). The results of the investigations by several researchers [38]–[40], had an impact size of 0.233 (95%- CI: -0.335; 0.800), 0.459 (95%- CI: -0.062; 0.980), and 0.361 (95%-CI: -0.122; 0.844).

Table 3. Results of effect size calculation

Code	SMD	95%-CI	%W (random)	Code	SMD	95%-CI	%W (random)
AR1	0.564	[0.048; 1.081]	3.729	AR15	0.579	[0.110; 1.047]	3.88
AR2	0.837	[0.309; 1.364]	3.692	AR16	0.814	[0.339; 1.290]	3.857
AR3	-0.119	[-0.625; 0.388]	3.76	AR17	2.059	[1.453; 2.666]	3.441
AR4	0.679	[0.159; 1.200]	3.715	AR18	1.346	[0.803; 1.889]	3.644
AR5	1.127	[0.518; 1.737]	3.432	AR19	1.178	[0.745; 1.612]	3.989
AR6	0.233	[-0.335; 0.800]	3.564	AR20	0.459	[-0.062; 0.980]	3.712
AR7	-0.181	[0.684; 0.322]	3.771	AR21	1.898	[1.472; 2.325]	4.01
AR8	1.649	[0.475; 2.823]	1.942	AR22	1.044	[0.552; 1.537]	3.804
AR9	1.455	[0.795; 2.116]	3.269	AR23	1.064	[0.543; 1.585]	3.714
AR10	1.074	[-0.201; 2.349]	1.754	AR24	0.361	[-0.122; 0.844]	3.835
AR11	1.04	[0.518; 1.562]	3.71	AR25	1.268	[0.694; 1.843]	3.543
AR12	0.884	[0.234; 1.533]	3.304	AR26	0.628	[0.168; 1.089]	3.904
AR13	0.822	[0.304; 1.341]	3.722	AR27	-0.113	[-0.619; 0.394]	3.76
AR14	1.185	[0.688; 1.683]	3.788	AR28	1.291	[0.783; 1.799]	3.755

To check whether the study effect sizes resulting from the studies included in this meta-analysis had a normal distribution or not a Normal Q-Q Plot was used. In meta-analysis, the Normal Q-Q Plot is used to test the assumption of normal distribution of study effect sizes (such as Hedges' g values or correlation coefficients) extracted from the pooled studies. Testing for normal distribution is important because many statistical methods in meta-analysis assume that study effect sizes are normally distributed among the included studies [41]. Normal Q-Q Plot Analysis in this meta-analysis is shown in Figure 2. It is important to note that the use of the Normal Q-Q Plot in meta-analysis is related to the assumptions underlying the statistical model used. Therefore, the results of the Normal Q-Q Plot must be analyzed carefully, and if abnormalities are found, appropriate methods or data transformations must be applied to ensure accurate and reliable meta-analysis results.

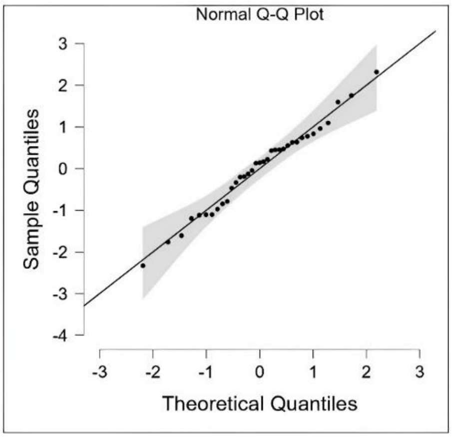

Figure 2. Normal Q-Q Plot analysis results

Utilizing the normal quantile plot in Figure 2, to see the distribution, use data from the research papers' effect size analyses that were included. The effect size data are shown as a distribution plot in Figure 2 based on the research study sample used in the meta-analysis. The effect size statistics of every research study show that the data are distributed with 95% confidence intervals around the line. Each effect size must be dispersed around the line and fall within the 95% confidence interval for the data to be considered normally distributed. This suggests a regularly distributed effect size distribution, with normal spacing between the two curved lines. To distinguish between the variation in how well traditional learning and learning based on ethnomathematics affect students' test scores on mathematical communication abilities, the studies considered in this meta-analysis must be integrated and statistically significant.

3.5. Forest plot

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 Jeffrey's amazing statistics program (JASP) application. The outcomes of the forest plot analysis utilizing the random effects model are displayed in Figure 3. The effectiveness of students' ethnomathematical learning is measured by effect size. Ethnomathematical learning has been able to assist students in strengthening their mathematical communication skills because the effect size of every research is larger than zero. Additionally, the figure demonstrates that each sample from a research paper considered in the meta-analysis had a statistically significant impact on the total effect size. The appropriateness of the study is determined by the limiting confidence interval for each effect magnitude. If the confidence interval does not include 0, the study is deemed to be statistically significant. Therefore, the 28 studies' impact sizes have non-zero confidence intervals, which has an impact on the summary effect sizes.

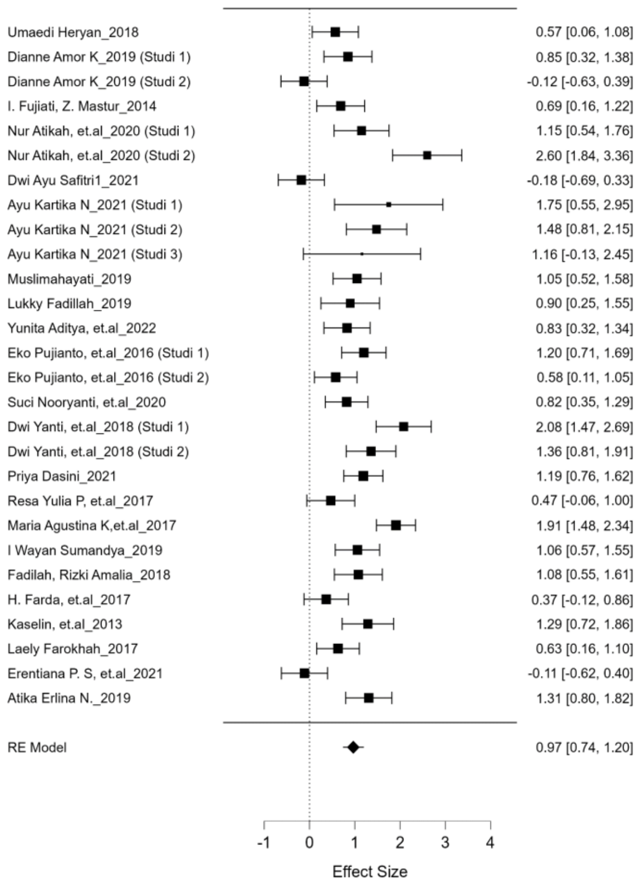

Figure 3. Results from a forest plot using random effects

3.6. Analysis of biased publication

Publication bias can significantly distort the results of a meta-analysis. When only a subset of studies is included, typically those with positive or statistically significant results, the overall findings might be skewed, leading to inaccurate conclusions. Studies with non-significant or negative results are less likely to be published, especially in prestigious journals, which can create a distorted view of the overall body of evidence on a particular topic [42]. 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. Finding study results that are statistically significant but do not support the theory's formulation can be referred to as discovering publication bias. Reviews indicate that students' mathematical communication skills are improved more by using ethnomathematics-based learning methodologies than by traditional instruction. Because they used both learning strategies, 28 research articles employing descriptive data analysis were published in journals. On the other hand, publication bias was found using the Fail-Safe N method.

The trim and fill approach are a step-by-step procedure that excludes studies with small sample sizes that significantly affect the forest plot's favorable side and recalculates effect sizes for each iteration until the funnel plot is level. The effect size distribution is represented by closed or open circles that form a funnel shape in the funnel plot graph. Publications are identified visually by analyzing the effect size distribution inside or outside the funnel. The distribution of effect sizes on either side of the 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 towards the bottom of the funnel plot graph or along just one vertical axis, publication bias is present [43]. The random effects model for every sample in a meta-analysis in Figure 4 is based on effect sizes and standard errors.

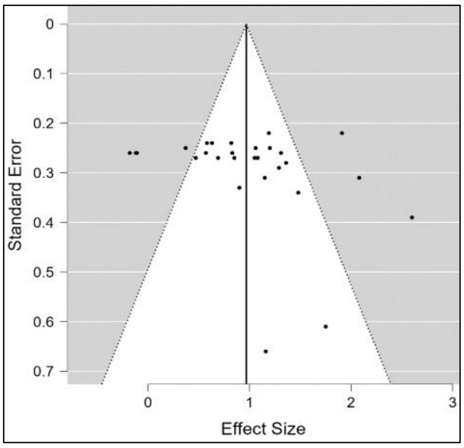

Figure 4. A funnel plot with models for the trim and fill

Figure 4 illustrates how the effects of traditional and ethnomathematical learning methodologies on students' mathematical communication skills varied among research. Figure 4's funnel plot results showed that the vertical line is symmetrically covered by the effect sizes. The findings do not show publication bias, despite experiments with closed circles outside the funnel's bottom and middle. It seems aesthetically subjective to use funnel plots to identify biased publications.

3.7. Discussion

The literature study identified 28 research publications that complied with the sample requirements for the meta-analysis in terms of sample size, mean, and standard deviation. Using a cooperative learning model in the experimental class and a traditional learning model in the control class, conduct a descriptive analysis. The benefit of ethnomathematical learning for enhancing students' mathematical communication skills is statistically significant for each research subject. The effectiveness of ethnomathematical and conventional learning on students' mathematical communication skills is reliably combined. According to Turgut [44], the effect size of ethnomathematics learning was 0.97 (95%-CI: 0.74; 1.20). Ethnomathematical-based learning is more effective when compared to traditional learning. Teachers in Indonesia believe that learning about different cultures through mathematics is more concrete for children, in addition to being enjoyable and meaningful. This study found teachers' positive perceptions about the ethnomathematical approach and suggests adopting ethnomathematics in the Indonesian mathematics curriculum.

Sunzuma and Maharaj [45], [46] found that participating teachers (60%) used examples of culture and geometry teaching activities, as learning materials and resources, as contexts for teaching geometry. While Abiam *et al.* [47] ethnomathematics-based instructional approach uses cultural artifacts that are found in the learner's locality in teaching geometry. The findings of the study have shown that their use in geometry instruction enhances pupils' learning and better achievement than the conventional method. Both approaches significantly enhance students' understanding of mathematics and their communication skills. According to Umbara *et al.* [48], mathematical ideas and practices that are owned and used from generation to generation by the Cigugur indigenous people, especially in determining the exact day when they start housing construction, can be seen in various aspects, mainly based on the cultural aspect. To improve students' mathematical problem-solving skills, teachers must design lessons that more often present more realistic and projected problems so that students can better relate mathematical concepts to the real world, especially to their culture [49].

4. CONCLUSION

This meta-analysis shows that ethnomathematics-based learning improves students' mathematical communication skills. The effectiveness of ethnomathematical and conventional learning on students' mathematical communication skills is combined reliably. The effect size of ethnomathematics learning was 0.97 (95%-CI: 0.74; 1.20). Ethnomathematics-based learning is more effective when compared to traditional learning. The results of forest plot analysis using a random effect model showed that the effectiveness of students' ethnomathematical learning was measured by effect size.

Ethnomathematics learning has been able to help students strengthen their mathematical communication skills because the effect size of each study is more significant than zero. In addition, each sample of the research papers considered in the meta-analysis had a statistically significant impact on the total effect size. The suitability of the study is determined by the limiting confidence interval for each magnitude of effect. The results of the funnel plot show that the vertical line is symmetrically closed by the size of the effect. The findings do not indicate publication bias, although there have been experiments with closed circles outside the bottom and middle of the funnel. It seems aesthetically subjective to use funnel plots to identify biased publications. The results of research studies published in the indexed journals SINTA and GARUDA show that theory construction generally has a statistically significant impact. The collection of research projects done in Indonesia and the examination of descriptive data from studies used in the meta-analysis published in publications indexed by Google Scholar, GARUDA, and SINTA are the study's limitations. As a result, recommendations for more research incorporate the findings of research studies while taking into account their global reach to inform teachers globally.

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