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Meta-analysis: Ethnomathematics approaches in mathematical learning in Indonesia

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Abstract

An introduction to ethnomathematics defines it as mathematics practiced among identified cultural groups. Ethnomathematics has a positive impact on the learning process, both as a moderate approach and as an approach to enhance numeracy literacy skills, for example. Previous researchers have conducted several studies on the ethnomathematics approach to mathematics education. However, the analysis presented has been highly varied. This study aims to determine the correlation between the ethnomathematics approach to mathematics education and students' mathematical abilities. This research utilizes a meta-analysis method, which combines multiple experimental studies that gather the effectiveness of ethnomathematics-based learning and regular learning in improving students' mathematical abilities. Relevant studies were searched through electronic resources from the National Library of Indonesia (Perpusnas) database using predetermined keywords. A total of 52 studies were obtained from the search, and eleven studies were selected based on inclusion and exclusion criteria. Meta-Mar was used to determine the combined effect size by analyzing the selected studies. This research indicates that the combined effect size of implementing ethnomathematics-based learning to enhance mathematical problem-solving abilities is 0.94, classified as a moderate effect. Therefore, it can be concluded that the ethnomathematics approach to mathematics education is related to students' mathematical abilities. Statistically, the implementation of the Ethnomathematics Approach in Mathematics Education is also influenced by study characteristics at the educational level.

Keywords: Educational Research; Ethnomathematics; Indonesia; Meta-Analysis

1. Introduction

Mathematics plays an important role in education, so mathematics becomes a necessary subject at every level of school. The importance of mathematics is revealed by Kline (2011), who reveals that mathematical excellence is to help understand and master social, economic, and natural problems in everyday life. As a tool, math is used to solve problems in various fields whose roles are crucial to daily life. Mathematics can train rigor and agility and can help solve problems (1). Sehingga pembelajaran matematika perlu disajikan oleh guru dengan cara yang menarik dan memberikan pengalaman belajar bagi siswa. Terdapat berbagai pendekatan dan model pembelajaran yang menarik yang dapat diterapkan dalam kegiatan pembelajaran matematika (2).

Culture is an inheritance passed on from generation to generation in everyday life. Since culture is a comprehensive and evenly distributed entity within society, mathematical ideas and facts can be integrated into everyday life by understanding specific methods that enhance verbal mathematics understanding. Learning and culture are interrelated. The learning process occurs through interaction between educators and learners in a community. Traditional culture is an integrated way of thinking that encompasses attitudes, beliefs, values, and symbols that are unconsciously accepted by a group of societies and passed down through the process of communication. In this case, customary culture can be integrated into learning because culture is also a learning material (3).

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Ethnomatematics presents mathematical learning that integrates it with the values, norms, and products of human thought that are rooted in the lives of different societies. With ethnomathematics-based learning, it is expected to cultivate a love of the student's homeland and culture, preserve the environment, and explain how mathematics is useful in life. Ethnomathematics in mathematical learning, according to Schoenfield in Zaenuri, can be used for. 1) Encourage students to think that mathematics is an integral part of everyday life; 2) improve their ability to find relationships between mathematical concepts in different contexts through mathematic problem-solving activities both individually and in groups. This statement suggests a positive link between ethnomathematics and mathematical problem-solving capabilities. (4).

A lot of research has been done on the implementation of ethnomathematics-based learning, mainly to analyze the impact of its implementation on improved mathematical problem-solving capabilities. Several studies have shown such results. Nur et al research suggests that mastery of mathematics can be enhanced through learning ethnomatematics. In addition, according to Nur et al, the ability to solve mathematical problems can be enhanced by involving ethnomathematics.(5). Research conducted by Maidiyah also showed similar results. They wanted to know if a model of counseling equal to an ethnomathematical basis influenced students' problem-solving skills. They restrict mathematical subjects to square-length matter. Maidiyah mentioned the positive and significant relationship between learning models and problem-solving abilities and concluded that problem-solving skills could be enhanced by applying a model of guidance equal to ethnomatematics in mathematical learning(6).

Research on ethnomathematics and its impact on the value of mathematical learning has not been much done. This is also reflected in the research conclusions (7) and the ethnomatematics literature research by (8) which state that about 75% of the research published in the accredited journal SINTA is qualitative ethnographic research, 10% is development research, and the rest is quantitative research. Due to the minimality of quantitative experimental research, the aim of this meta-analysis research is to gain a more comprehensive understanding of the impact of learning using ethnomathematics on students' mathematical learning outcomes.

2. Material and methods

Research methods include meta-analysis through a review of articles in national journals. Meta-analysis is a statistical method for systematically combining, analyzing, and synthesizing several studies in order to obtain the latest findings and conclude them with a study effect. (Rohmatulloh et al., 2022). Borenstein (2009) says the metaanalysis stages are: determination of inclusion criteria for study analysis, empirical data gathering procedures, as well as explaining the coding of study variables and describing statistical techniques. The following primary research studies relate to ethnomathematical approaches to mathematical learning. The article in the primary study is the following research with the established inclusion criteria, namely:

- The year of publication of the article was from 2018 to 2023.
- Articles with research methods of experimental quarantine and design: randomized control group pretest-posttest design, randomized control group posttest-only design, nonequivalent Qroup pretest-pposttest design, and nonecuivalent Qroup design posttest-only.
- Articles with primary study In this research, the articles that are the main focus involve student populations from primary (SD), secondary (SMP), and upper (SMA) education levels in Indonesia.
- The study article with statistical data on the primary study is the size of the sample, average, and standard deviation.

The article search was done in databases such as Google Scholar and the Garuda Portal with keywords "Ethnomathematic, Etnomatematics". Based on the search carried out for the year of publication 2018-2023 there are 53 articles were found. From this article will be selected based on the inclusion criteria and finally the study that meets the criteria there are 11 articles were selected that met these criteria. These articles cover studies at primary (SD), secondary (SMP/MTs), and upper (SMA/equivalent) education levels.

The next process is carrying out study coding. The instrument used in this process is a coding protocol which can be a coding form on paper or a computer, as well as a manual guide that explains how to code each item based on data in the primary study(4). . Coding this study includes information such as study code, author, year of publication, mean, standard deviation, and number of samples in the experimental group and control group, as well as educational level and year of research (9). After the coding process is complete, the effect size is calculated using the standardized mean difference known as Hedges's g Interpretation of research results refers to the guidelines put forward by Cohen (Parno et al., 2020). The formula for calculating Hedges's g is as follows :

$$\text{Hedges'g} = \frac{M_1 - M_2}{SD^{*}pooled}$$

explanation:

M1-M2 = difference in means,
SD*pooled = pooled and weighted standard deviation

Meanwhile, the interpretation of the effect size is shown in Table 1 below:

Table 1 Interpretation of Effect Sizes

Effect Size	ES Interpretation
0 ≤ ES ≤ 0.20	Low effect
0.20 < ES ≤ 0.50	Simple effect
0.50 < ES ≤ 1.00	Medium effect
ES > 1.00	Strong effect

The next process will be carried out with a homogeneity test using p-value to determine the analysis model. If the p-value < 0,05, when it has a heterogeneous nature, with the analysis model using a random effects model and if the p-value > 0,05, then it has a homogeneous, with the analysis model using a fixed effects model (9) . In order to prevent incorrect representation in the findings, it is necessary to check for publication bias.

Studies that have been published are more likely to be included in the meta-analysis than their unpublished counterparts, which raises concerns that meta-analyses can overestimate the original effect size (10). Methods for detecting and resolving publication bias include funnel plots and Rosenthal's Fail-Safe N (9). The initial way to detect publication bias is to use a funnel pot. If the distribution of study effect sizes is asymmetrical or not completely symmetrical, Rosenthal's FSN will be used to make it easier to determine the presence of publication bias. When the value of $\frac{FSN}{(5k+10)} > 1$ where k is the number of studies in the meta-analysis, the study is held against publication bias. If there is no publication bias, the analysis process will continue. Through the analysis model, the author can test H0 [12]. If the p-value < 0,05, then H0 will be accepted. If the analysis model uses random effects where there are different research characters, then the author can analyze the research character and interpret the results of the analysis (10).

3. Results and discussion

The aim of the following research is to determine the size of the combined effect of applying the Ethnomathematics Approach in Mathematics Learning and obtain results regarding the effect of applying the Ethnomathematics Approach in Mathematics Learning. The following is a list of studies in the following research.

Table 2 Studies Used in Meta-Analysis

Study Code	Year of publication	Name of Journal/ Proceeding & URL
E1	(11)	Jurnal Edukasi dan Sains Matematika (JES-MAT) URL : https://journal.uniku.ac.id/index.php/JESMath/article/view/1722
E2	(12)	JNPM (Jurnal Nasional Pendidikan Matematika) URL : http://jurnal.ugj.ac.id/index.php/JNPM/article/view/2549
E3	(13)	CIRCLE : Jurnal Pendidikan Matematika URL: https://e-journal.uingusdur.ac.id/index.php/circle/article/view/4207
E4	(14)	JURIDIKDAS: Jurnal Riset Pendidikan Dasar

		URL: https://ejournal.unib.ac.id/juridikdasunib/article/view/14486
E5	(15)	Jurnal Fibonaci: Jurnal Pendidikan Matematika URL: https://jurnal.unimed.ac.id/2012/index.php/JFi/article/view/28665
E6	(16)	Jurnal Adat dan Budaya Indonesia URL: https://ejournal.undiksha.ac.id/index.php/JABI/article/view/28906
E7	(17)	Jurnal Pendidikan Matematika Raflesia URL: https://ejournal.unib.ac.id/jpmr/article/view/6290
E8	(18)	Jurnal Pendidikan Matematika Raflesia URL: https://ejournal.unib.ac.id/jpmr/article/view/10664
E9	(5)	JRAMathEdu (Journal of Research and Advances in Mathematics Education) URL : https://eric.ed.gov/?id=EJ1281078
E10	(19)	Jurnal Pendidikan Matematika Raflesia URL: https://ejournal.unib.ac.id/index.php/jpmr/article/view/6284
E11	(20)	PRISMA:Prosiding Seminar Nasional Matematika 3 URL: https://journal.unnes.ac.id/sju/index.php/prisma/article/view/37565

By using the website https://www.meta-mar.com/, the study effect, standard error, and confidence interval for each study were obtained based on the standardized mean difference namely Hedges's g, which is presented in Table 3 below.

Table 3 Effect Size, Interpretation, Standard Error, and Confidence Interval of Each Study

Study Code	**Ukuran Efek**	**Interpretation of Effect Sizes**	**SE**	**Confidence Interval**	
				Lower limit	Upper limit
E1	0.884	Medium	0.331	0.234	1.533
E2	0.846	Medium	0.207	0.455	1.267
E3	0.876	Medium	0.163	0.546	1.187
E4	0.966	Medium	0.112	0.700	1.138
E5	0.181	Low	0.214	0.263	1.103
E6	3.146	Strong	0.447	0.194	1.947
E7	0.565	Simple	0.385	0.204	1.750
E8	1.415	Strong	0.337	0.384	1.707
E9	0.561	Simple	0.303	0.396	1.583
E10	0.250	Low	0.281	0.363	1.466
E11	1.250	Strong	0.256	0.442	1.445

Based on Table 3, each study had varying effect sizes, with 11 studies having effect sizes between 0.18 and 1.41. By interpreting the effect size according to Cohen's classification, information was obtained that 3 studies had a strong effect size, or the application of ethnomathematics learning in these 3 studies had a strong influence on students' mathematical abilities; 6 studies were medium-sized, or the application of ethnomathematics learning had a moderate effect on students' mathematical abilities; and there were 2 studies. The simple size of ethnomathematics learning in this study had a modest influence on students' mathematical abilities.

In order to determine the combined effect size for all primary studies, the author must create an estimation model by testing the homogeneity of all studies. Table 4 provides information regarding the homogeneity test for all primary studies.

Table 4 Heterogeneity of Effect Size Distributions

Heterogeneity			
Chi-Square	df	P-Value	I-Square
69.048	10	0.00	90.734

Based on Table 4, there is a p-value < 0.05, meaning that the distribution of the effect sizes of the meta-analyzed primary studies is heterogeneous. Therefore, the estimation model to determine the combined effect size is a random effects model. Then, the identification of publication bias was carried out using the funnel plot shown below.

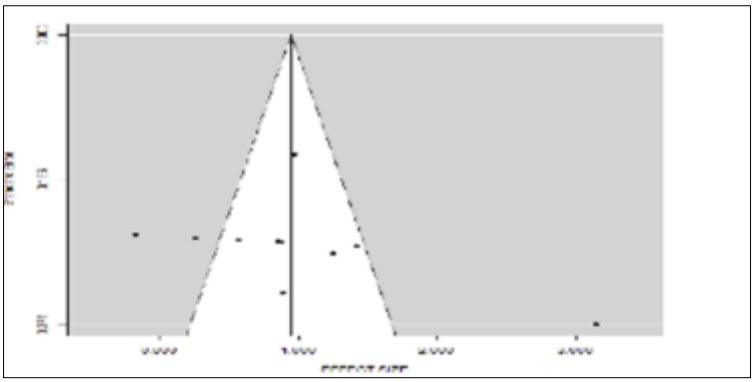

Figure 1 Funnel Plot

Based on Figure 1, the study effect size distribution is asymmetrical. So, the authors detected publication bias with Fail-Safe N (FSN) 527 of the observed studies (k) as many as 9.

With
Using the formula $\frac{FSN}{5K+10} = \frac{527}{5(8)+10} = 1{,}317 > 1$, the conclusion is that the studies in this meta-analysis have sufficient tolerance for publication bias (9).

Next, Table 5 shows the results of meta-analysis from primary studies with fixed effect and random effect models.

Table 5 Meta-Analysis Results Based on Estimate Model

Models	**n**	***Effect Size* and 95% Confidence Intervals**				***Tes of null (2-Tail)***	
		Effect Size	SE	Lower Bound	Upper Bound	Z-Value	P-Value
Fixed Effect Model	11	1.247	0.052	1.145	1.349	23.862	0.00
Random Effect Model	11	0.929	0.255	0.429	1.430	3.638	0.00

Using a random effects estimation model shows that the p-value is 0.00 or less than 0.05. Based on the hypothesis testing criteria, it can be said that overall, the ethnomathematics-based learning model has a significant influence on mathematical problem-solving abilities compared to ordinary learning models. This conclusion is in line with other research, such as research conducted by (21).(22) concluded that ethnomathematics-based mathematics learning has a significant influence and is also more effective in improving learning outcomes compared to groups of students. who apply the ordinary learning model. Based on these results, it can be seen that ethnomathematics-based mathematics learning is an alternative for teachers to improve student learning outcomes, especially in mathematics learning.

In addition, based on a random effects model with a 95% confidence level, the combined ES (effect size) of all studies was 0.929, which, based on the interpretation of Cohen et al. (2007), this ES is classified as a strong effect. Thus, it can be said that the ethnomathematics-based learning model has a strong effect in improving mathematics learning.(21)

According to Coe (2002), a combined ES of 0.929 indicates that the mathematical problem-solving abilities of students in the experimental group are higher than the mathematical problem-solving abilities of 84% of students in the control group. In the previous homogeneity test, information was obtained that the main study ES data followed an inhomogeneous distribution. The next step is to analyze research characteristics that are thought to be the cause of the inhomogeneity of ES data on mathematical problem-solving abilities. For this reason, an analysis of research characteristics was carried out, namely: year of research, level of research, sample size, and learning model. The results of the characteristic analysis can be seen in Table 6 below.

Table 6 Meta-Analysis Results of Each Study Characteristic

Study characteristics	Category	n	Hedge's g	Lower limit	Upper limit
Year of research	2018 – 2020	8	1.085	0.469	1.710
	2021 – 2023	3	0.570	-0.153	1.291
Educational level	Elementary school	2	2.013	-0.122	4.148
	Junior high school	6	0.699	0.312	1.085
	High school	3	0.731	0.051	1.411
Sample size	≤ 30	4	0.537	0.224	0.849
	> 31	7	1.145	0.404	1.886
Learning Ability	Problem Solving	5	0.280	-0.141	0.701
	Communication	3	0.367	-0.245	0.979
	learning outcomes	2	1.973	-0.250	4.196
	Literacy	1	0.966	0.700	1.138

From table 6 above, for research characteristics in the form of research year, it can be seen that research conducted in 2018–2020 has an ES of 1.085, which is classified as a lever effect, while research conducted in 2021–2022 has an ES of 0.570, which is also classified as a medium effect. This shows that each group in the research year has a significant influence on the ethnomathematics approach to learning mathematics. These results are in line with research conducted by (23) which shows that the ES of environment-based learning (ethnomathematics) studied from 2016 to 2020 is in the medium and strong categories.

For education level, it can be seen that research conducted at the primary education (SD) level provides an ES of 2.013, which is classified as a strong effect, better than research at the upper secondary education (SMA) level, which provides an ES of 0.731, which is classified as a medium effect. Research at the junior secondary education (SMP) level provides an ES of 0.69, which is classified as a medium effect, similar to research conducted in tertiary institutions with an ES of 0.82, which is classified as a medium effect. This shows that middle school and high school education levels have the same influence on the ethnomathematics approach to learning mathematics. These results show similarities to research conducted by Tungga (2021), which states that the educational levels studied, namely junior high and high school levels, in the application of ethnomathematics have the same effect on student learning outcomes, which are included in the strong effect category (4).

For sample size characteristics, it can be seen that research with a sample size below or equal to 30 people has an ES of 0.537 in the moderate category, while research with a sample size above or equal to 31 people has an ES of 1.145 in the strong category.

For the characteristics of learning ability, it can be seen that the ES of research conducted using the ethnomathematics approach is 1.9731, the strong effect category. Meanwhile, literacy skills provide an ES of 0.966, which is included in the medium effect. Apart from that, the ethnomathematics approach, problem solving, and mathematical communication

abilities provide an ES of 0.280 and 0.367, respectively, which are in the same category and have the Simple category. This shows that the effect of the ethnomathematics approach is high on learning outcomes.

4. Conclusion

The meta-analysis results of 11 main studies discussing the influence of the ethnomathematics approach in mathematics learning in Indonesia show that the combined ES of all studies is 0.92. Based on the classification of Cohen et al. (2007), this figure is included in the slightly strong (medium) effect size category. This means that the ethnomathematics approach to learning mathematics has a strong influence on improving students' mathematical abilities. Apart from being more meaningful, the effects provided are also more effective when compared to implementing ordinary learning models. By considering the characteristics of the main study, it can be concluded that middle school and high school education levels have different effects on mathematical abilities. In other words, the ethnomathematics approach to mathematics learning and improving mathematics abilities is influenced by the characteristics of the level of education.

Compliance with ethical standards

Disclosure of Conflict of interest

No conflict of interest to be disclosed.

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