Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika
Volume 7, Issue 2, 260-274, December 2025
e-ISSN: 2715-6109 | p-ISSN: 2715-6095
https://journal.ibrahimy.ac.id/index.php/Alifmatika

A meta-analytic review of the impact of ethnomathematics-based instruction on students' conceptual understanding in mathematics

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Received: April 28, 2025 | Revised: October 2, 2025 | Accepted: November 15, 2025 | Published: December 15, 2025
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***Abstract*:**
Ethnomathematics-based learning has been implemented in various regions as an approach to mathematics education. This meta-analysis investigates the overall effectiveness of ethnomathematics-based instruction in enhancing students' conceptual understanding of mathematics, while also examining the extent to which study characteristics influence its impact. The literature search was carried out for studies published between 2018 and 2023 using the Google Scholar database, facilitated by Harzing's Publish or Perish software. As a result of the screening process, eight studies that fulfilled the predefined inclusion criteria were selected for data extraction. Data analysis was performed using the OpenMEE software, employing a random-effects model for effect size estimation. The findings indicated a substantial overall effect size of 1.330, suggesting that ethnomathematics-based learning exerts a significant positive influence on students' conceptual understanding of mathematics. Analysis of study characteristics revealed that studies conducted at the elementary school level, employing cluster random sampling and involving fewer than 30 participants, demonstrated greater effectiveness of ethnomathematics-based learning. These findings may serve as considerations for mathematics education practitioners in implementing ethnomathematics-based learning in the future. In particular, the results highlight the urgency for teachers and curriculum developers to integrate local cultural contexts into mathematics instruction as a strategy to foster deeper conceptual understanding, increase student engagement, and support equitable learning outcomes.

Keywords: Conceptual Understanding; Ethnomathematics; Matematics; Meta-Analysis.

How to Cite: Prasetyawan, E., & Masitoh, L. F. (2025). A meta-analytic review of the impact of ethnomathematics-based instruction on students' conceptual understanding in mathematics. *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika*, 7(2), 260-274. https://doi.org/10.35316/alifmatika.2025.v7i2.260-274

Introduction

Comprehending mathematical concepts is a crucial skill in the study of mathematics. Additionally, the capacity to comprehend mathematical concepts is fundamental to the acquisition of mathematical knowledge (Lambertus, 2016). Understanding mathematical concepts involves restating learned concepts, identifying examples and non-examples, and classifying objects according to specific properties in accordance with the concept (National Research Council, 2001). Conceptual understanding refers to the ability to master concepts, operations, and relationships in mathematics (Killpatrick et al., 2001; Tiani et al., 2019). This ability is considered one of the components of mathematical proficiency (Killpatrick et al., 2001). Without a strong understanding of these concepts, students will have difficulty relating mathematics to real situations or applying their knowledge in the context of complex problems (Marlena & Nugrheni, 2019; Yanti Ginanjar, 2019; Radiusman, 2020). Understanding mathematical concepts also involves the ability to see patterns, formulate relationships, and understand the basic principles underlying various mathematical topics. It will certainly help students in solving mathematical problems (Yanti Ginanjar, 2019; Nurfarikhin, 2010).

The importance of this ability in learning mathematics certainly needs to be developed to the maximum. This competence may be developed by implementing appropriate instructional strategies (Freeman-Green et al., 2015). Integrating ethnomathematical perspectives into instruction offers a promising way to strengthen learners' conceptual grasp of mathematics (Sarwoedi et al., 2018; Mei et al., 2021; Nur Azmi & Rosdiana, 2022). Ethnomathematics refers to the forms of mathematics practiced within cultural groups, including urban and rural communities, labor groups, professional classes, children of specific age groups, indigenous societies, and various other communities that are characterized by shared objectives and common traditions (D'Ambrosio, 2001). Ethnomathematics describes the mathematics embedded in the everyday life of cultural groups. It highlights how communities produce and employ specific forms of mathematical thinking expressed through language, symbolic systems, myths, and technical practices such as ordering, measuring, and modeling to interpret, cope with, and shape their social and natural environments (Rosa & Orey, 2011). Ethnomathematics embraces the idea that mathematical concepts can be discovered and understood through the lens of students' culture and life experiences. This approach not only teaches mathematics skills but also recognizes the values, traditions, and social contexts that influence students' understanding of mathematics.

The integration of ethnomathematics into mathematics learning has been shown to strengthen students' conceptual understanding. A study conducted at senior high schools in Bengkulu revealed that students taught through realistic mathematics education based on ethnomathematics achieved higher average scores in conceptual understanding than those taught using conventional methods, even after controlling for their initial abilities (Febriani et al., 2019). Similarly, research at SMPN 1 Bangkinang Kota demonstrated that the application of the Ethno-RME approach significantly improved students' conceptual understanding, with a moderate level of effectiveness, whereas conventional teaching was found to be less effective (Mona Lisa Rahmadani et al., 2023). These findings indicate that embedding ethnomathematics within realistic contexts not only provides more meaningful learning experiences but also makes a substantial contribution to enhancing students' ability to understand, connect, and apply mathematical concepts more deeply.

The impact of ethnomathematics-based instruction on students' understanding of mathematical concepts has gained growing attention as a prominent focus in recent educational research. Ethnomathematics fosters a more relevant and engaging learning environment for students by incorporating local cultural elements into the mathematics curriculum. Through this approach, mathematical concepts are no longer considered as separate entities from students' daily reality, but rather as tools that can be used to understand and solve problems in the context of their lives.

In recent years, many studies have explored the link between ethnomathematics-based instruction and students' conceptual understanding in mathematics. Findings from some of these studies indicate that mathematics instruction grounded in ethnomathematical principles can significantly improve students' grasp of mathematical concepts (Nur Azmi & Rosdiana, 2022; Sarwoedi et al., 2018; Mei et al., 2021). Conversely, other studies present contrasting findings, including the research of Faiziyah et al. (2022), which asserts that ethnomathematics education has not effectively enhanced students' mathematical creative thinking skills. Numerous studies indicate a strong association between creative thinking and the comprehension of mathematical topics (Karyanto, 2022; Trianggono, 2017). It might be argued from the previous two sentences that ethnomathematics does not enhance comprehension of mathematical concepts, which is contrary to the research findings given earlier in the paragraph.

The disparity among existing research results reflects an inconsistency regarding the impact of ethnomathematics-integrated teaching on students' comprehension of mathematical concepts. As a result, this inconsistency may affect the ability to draw objective conclusions. Accordingly, conducting a meta-analysis is essential. This method serves as a quantitative approach that synthesizes effect sizes from comparable studies addressing a common topic, enabling comprehensive conclusions regarding the strength of the effect and the relationships among variables (Suparman et al., 2021). The purpose of meta-analysis is to evaluate several primary studies on a specific issue, accommodating variances in effect size (Tamur et al., 2020). Meta-analysis is regarded as a prevalent method for aggregating results from multiple primary investigations, comparing various therapies (White, 2015), and providing a broader summary and explanation (Stanley et al., 2013).

Furthermore, meta-analysis yields cumulative evidence by mitigating the biases inherent in primary investigations, which reduces differences in results and helps understanding and theory development by finding relationships between study characteristics (Schmidt & Hunter, 2015). To date, no study has investigated the effect of ethnomathematics learning on students' ability to understand mathematical concepts. Nevertheless, conceptual understanding in mathematics plays a crucial role in effectively addressing mathematical problems. Thus, obtaining precise information about the impact of ethnomathematics-oriented instruction on conceptual understanding is critically important for informing educational practice. It is also hoped that educators will be more confident in using ethnomathematics in the classroom.

This study aims to quantify the impact of ethnomathematics-based learning on students' conceptual understanding of mathematics. In addition, this study will also investigate the extent to which study characteristics affect the success of ethnomathematics learning. Based on this rationale, undertaking a comprehensive meta-analysis to evaluate the effectiveness of ethnomathematics-based learning on Indonesian students' mathematical abilities over the past five years (2018–2023) is of significant importance. It is essential to assess its utilization and discern the overarching trend with more clarity.

Research Methods

This kind of research encompasses quantitative research. This research used the meta-analysis method to synthesize two or more published primary investigations, to consolidate the findings (Schmidt & Hunter, 2015). This study aims to investigate empirical research that explores the impact of ethnomathematics-based instruction on students' understanding of mathematical concepts. The study adopts the standard meta-analytic framework proposed by Pigott (2012), which involves establishing inclusion criteria, gathering and coding relevant data, and performing statistical evaluation.

Inclusion criteria to check and assess the suitability of research data with the focus of this research include: (1) Sourced from journals, proceedings, theses, and dissertations; (2) Research studies in the period 2018-2023; (3) Research studies have minimum data information for the experimental and control classes, including sample size, average and standard deviation; and (4) The research was carried out in Indonesia.

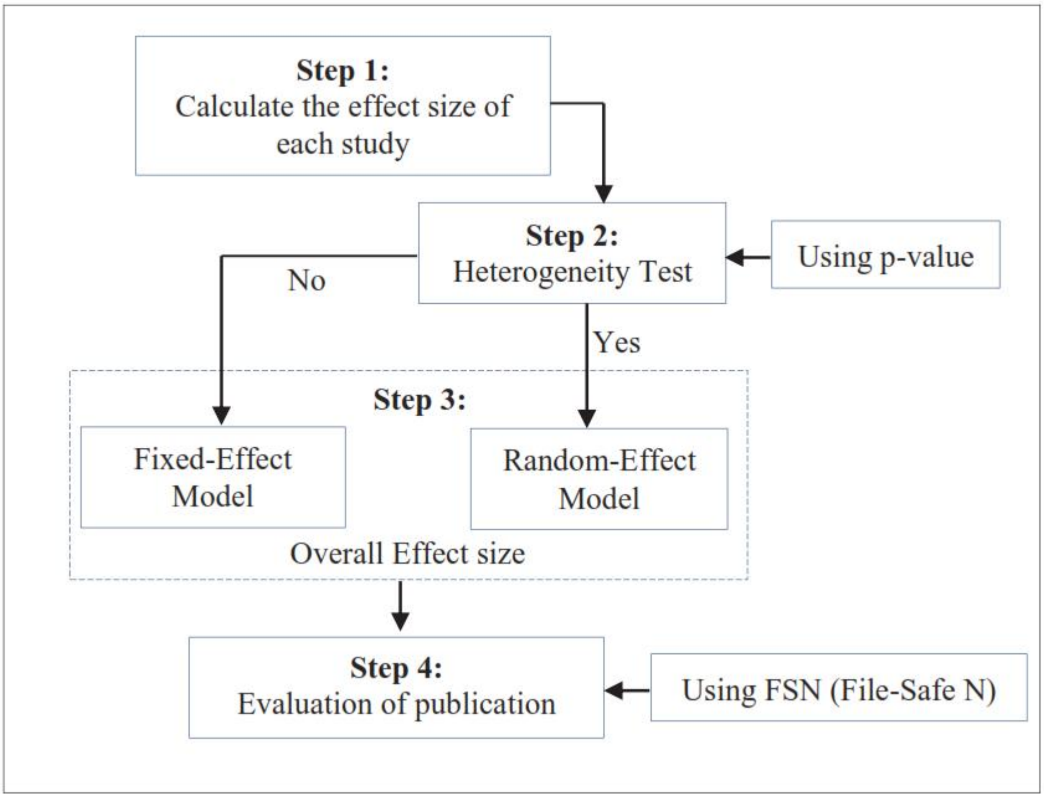
Data coding represents a critical step in meta-analysis where salient information from each included study is systematically transformed into a structured data format (either numeric or categorical), ready for statistical analysis. This process involves the systematic extraction of two main types of variables: first, the Study Descriptors, which encapsulate the methodological and contextual characteristics (such as publication year, study design, and participant demographics); and second, the Statistical Outcome Variables, which are the essential quantitative data (mean, standard deviation, and sample size) required for calculating the effect size. To ensure objectivity and reliability, coding is executed using a standardized coding sheet. It often involves cross-checking by a second reviewer (*double-coding*) to measure and ensure data consistency before proceeding to the analytical stage.

To obtain research data, Harzing's Publish or Perish application was used as a study search engine. Data search uses a database indexed on Google Scholar. The keywords used are "Ethnomathematics" and "Ability to understand mathematical concepts." Eight eligible studies were selected based on the inclusion criteria and served as data sources for this meta-analysis, as shown in Table 1.

Table 1. Search Data Results

No	Name	Year	Experimental Class			Control Class		
			N	Mean	Sd	N	Mean	Sd
1	Lailatul Fajriyah & Dian Anggraeni Maharbid	2023	32	80.37	11.67	32	76.00	14.20
2	Kadek Rani, dkk	2023	35	67.66	13.10	30	44.80	18.18
3	Vini Nurfauziah Apriani	2023	30	87.13	5.54	25	81.76	6.19
4	Silvi Kirani Agustin	2023	26	77.96	15.03	26	61.92	16.28
5	Muspiqotus Sadiyah	2023	28	77.46	4.18	28	63.71	4.23
6	Widad Rifda Ul-Haq	2023	23	84.09	13.98	23	59.35	17.12
7	Maimunatul Fadhilah, dkk	2022	30	84.31	9.46	30	66.94	9.91
8	Rezkiatu Novia Alhikmah	2019	23	73.56	11.58	23	64.47	14.93

Based on Picture 1, statistical analysis in a meta-analysis is carried out through several systematic stages. The first step involves calculating the effect size for each selected study. This effect size serves as the foundation for comparing results across studies. The second step is a heterogeneity test, which is performed to assess the degree of similarity or variation among the included studies. This test is commonly based on the p-value. If the findings indicate homogeneity (no significant differences across studies), the analysis proceeds using the Fixed-Effect Model. Conversely, if significant heterogeneity is detected, the Random-Effect Model is applied to obtain a more reliable estimation. In the third stage, regardless of whether the Fixed-Effect or Random-Effect Model is employed, the overall effect size or the combined effect derived from all studies is calculated. Finally, the fourth step addresses publication bias evaluation, which is typically conducted to examine the possibility of unpublished studies influencing the results. One of the techniques frequently used is the File-Safe N (FSN), which helps determine the robustness of the meta-analysis against the risk of missing studies. By following these stages, a meta-analysis is able to produce more comprehensive and valid conclusions, providing a more accurate representation of the investigated relationships or effects.



Picture 1. Overview of Statistical Analysis Steps in This Meta-Analysis

The data analysis employed in this study involved calculating individual and overall effect sizes (ES), along with heterogeneity assessment and evaluation of publication bias. The effect size (ES) for each study was calculated using Hedges' g, as outlined by Borenstein et al (2009), and in accordance with the procedures described by Retnawati et al. (2018). In addition, the analysis process used the OpenMEE software. A random-effects model was applied to analyze the pooled effect size across all included studies. The selection of the random-effects model is grounded in the assumption that the analyzed study populations exhibit functional variability due to differences in the interventions implemented by various researchers (Borenstein et al., 2009). These disparities result in variations in sample characteristics and the implementation of treatment within the sample (Retnawati et al., 2018). Table 2 below shows the categories used in the calculation of effect size (Cohen et al., 2018).

Table 2. Effect Size Category

Effect Size	**Category**
0 – 0,20	Weak effect
0,21 – 0,50	Modest effect
0,51 – 1,00	Moderate effect
> 1,00	Strong effect

Results and Discussions

This meta-analysis commenced with the determination of effect sizes and the classification of each study. Effect sizes were calculated using the means, standard deviations, and sample sizes from both experimental and control groups. Table 3 below shows the effect size data after analysis.

Table 3. Effect Size Data and Categories

No	**Name**	**Year**	***Effect Size***	**Category**
1	Lailatul Fajriyah & Dian Anggraeni Maharbid	2023	0.332	Modest effect
2	Kadek Rani et al	2023	1.444	Strong effect
3	Vini Nurfauziah Apriani	2023	0.906	Moderate effect
4	Silvi Kirani Agustin	2023	1.008	Strong effect
5	Muspiqotus Sadiyah	2023	3.224	Strong effect
6	Widad Rifda Ul-Haq	2023	1.556	Strong effect
7	Maimunatul Fadhilah et al	2022	1.770	Strong effect
8	Rezkiatu Novia Alhikmah	2019	0.669	Moderate effect

Based on Cohen's categorization, the effect sizes in Table 3 above can be grouped into three groups, namely 1 study that has a modest effect, two studies that have a moderate effect size, and five studies that have a strong effect size. Overall, the study shows that the effect size is positive; this indicates that the experimental class has an advantage over the control class. It can be concluded that the implementation of ethnomathematics-based learning has a significant impact on enhancing students' conceptual understanding of mathematics. Of the eight studies analyzed, five demonstrated a *strong effect*, with effect size values ranging from 1.008 to 3.224. It indicates that integrating ethnomathematics into the learning process strengthens the connection between students' cultural experiences and formal mathematical concepts, thereby fostering deeper conceptual comprehension. Meanwhile, two studies showed a *moderate effect* with effect size values of 0.669 and 0.906, and one study demonstrated a *modest effect* with a value of 0.332. This variation suggests that although the effectiveness of ethnomathematics implementation may differ across contexts, in general, the approach positively contributes to students' learning outcomes.

These findings are consistent with Rosa and Orey (2016), who emphasized that ethnomathematics plays a vital role in linking cultural practices to mathematical concepts, thereby increasing student engagement in the learning process (Rosa & Orey, 2016). Similarly, Achor, Imoko, and Uloko (2009) confirmed that culturally contextualized instructional strategies significantly enhance students' conceptual understanding of mathematics in the Nigerian context (Achor et al., 2009). Similar conclusions were drawn in the study by Saputro et al, who found that the problem-based learning model based on Ethnomathematics is more effective than conventional learning with the lecture method (Saputro et al., 2020).

Thus, the findings of this study reinforce the view that ethnomathematics is a relevant and effective approach in fostering students' conceptual understanding of mathematics. The integration of cultural elements into mathematics instruction not only provides meaningful learning contexts but also holds potential as an innovative pedagogical strategy to enhance the quality of mathematics education across different educational levels.

Next, a test for heterogeneity of effect sizes between studies was carried out. Based on analysis using OpenMEE, the following results were obtained.

Table 4. Heterogeneity Test

tau^2	**Q(df=7)**	**Het. p-Value**	**I^2**
0.514	**46.776**	**< 0.001**	85.035

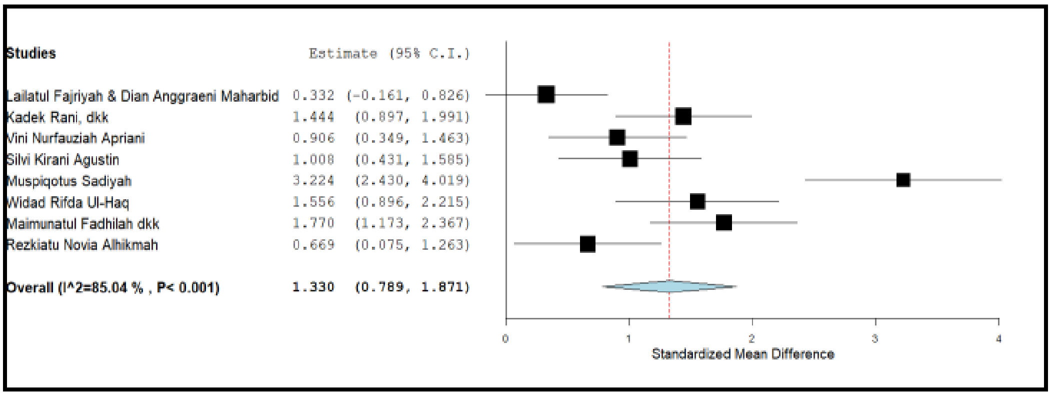
Based on Table 4, the Q value obtained is 46.776 > χ^2 (0.05;7) = 14.067 (Chi-square table) or by looking at the p-value < α = 0.05 which means accepting the alternative hypothesis (H_a). If you look at the value of I^2 = 85,035, a value of this magnitude is included in the substantial/ considerable heterogeneity range (Higgins & Thompson, 2002). Thus, it can be concluded that there is heterogeneity. Therefore, this research uses a random effect model as an estimation method.

Subsequently, the p-value was computed to test the research hypothesis, serving to assess the overall impact of ethnomathematics-based learning using the random-effects model. Table 5 and Picture 2 below show the results of the analysis.

Table 5. Results of the Analysis Using the Random-Effects Model

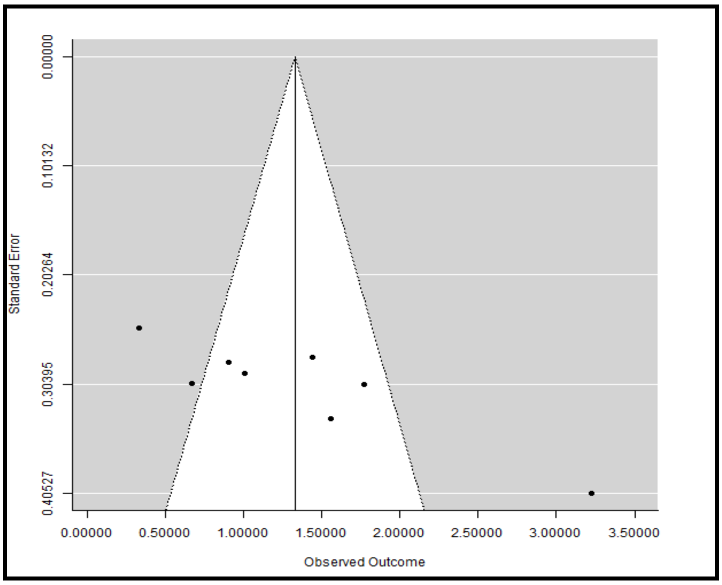
Estimate	**Lower bound**	**Upper bound**	**Std. error**	**p-Value**
1.330	0.789	1.871	0.276	**< 0.001**

As shown in Table 5 and Picture 2, the pooled effect size was calculated at 1.330 with a standard error of 0.276, indicating a strong effect (Cohen et al., 2018). Additionally, the results were statistically significant with a p-value of less than 0.001. These findings suggest that ethnomathematics-based learning has a substantial positive impact on students' conceptual understanding of mathematics. The wide confidence intervals indicate that although there is variability between studies, there is no doubt that the effect is positive. These findings are in line with previous meta-analyses, such as Effectiveness of ethnomathematics-based learning on students' mathematical literacy, which reported strong effectiveness (≈1,163) in improving students' mathematical literacy (Pratama & Yelken, 2024). In addition, the Meta-analysis Study of the efficacy of the ethnomathematical approach on Students' Achievement also found a very large combined effect (d = 1.35) compared to conventional learning (Sulistyowati & Sayuti, 2024).



Picture 2. Forest Plot of Effect Sizes

The subsequent step involves analyzing publication bias using a random-effects model to determine if there is a propensity for study sources to report exclusively significant findings, resulting in meta-analyses that fail to represent the population accurately. Publication bias is evaluated using a funnel plot analysis. An absence of bias is indicated when the effect sizes of the studies are symmetrically distributed around the vertical axis (Borenstein et al., 2009). Based on analysis using OpenMEE software, the following results were obtained.



Picture 3. Funnel Plot of Effect Sizes

Picture 3 reveals a degree of asymmetry in the distribution of effect sizes relative to the central line, implying that the observed effect size might not accurately capture the true effect (Borenstein et al., 2009). A Fail-safe N (FSN) test was conducted using Rosenthal's approach to assess the potential for publication bias. According to Mullen et al. (2001), a study can be considered robust against publication bias if the value of FSN satisfies the criterion FSN / (5k + 10) > 1, where k denotes the number of studies analyzed. Using the OpenMEE software, the FSN value was found to be 412. With k = 8, the calculation yields 412 / (5×8 + 10) = 8.24, which is greater than 1. These findings indicate that the study is relatively robust against potential publication bias, and the inclusion of additional studies to mitigate such bias is not warranted. Similar approaches were also applied in recent meta-analyses of ethnomathematics-based learning, such as Pratama and Yelken (2024), who employed funnel plots, Egger's regression test, and the trim-and-fill method to confirm the reliability of the findings. In line with these studies, the present analysis supports the conclusion that ethnomathematics-based learning has a significant and credible impact on students' conceptual understanding of mathematics, despite a minor indication of asymmetry in the funnel plot.

The next stage of this study involved analyzing the study characteristics or moderator variables. Based on the results of the previous heterogeneity test, the effect size of primary learning showed a heterogeneous distribution. This condition provides an opportunity to further investigate character education as a potential moderator in the relationship between ethnomathematics-based learning and students' conceptual understanding of mathematics. This study's analyzed characteristics included educational level, sampling method, and sample size. These moderating variables are assumed to affect the magnitude and direction of the relationship between the independent and dependent variables. The independent variable in this study is ethnomathematics-based learning, while the dependent variable is students' conceptual understanding of mathematics. The specified study characteristics are presumed to be the main sources of heterogeneity in the effect of ethnomathematics-based learning implementation on conceptual understanding. The complete results of the study's characteristic analysis are presented in Table 6 below.

Table 6. Analysis Results of the Included Studies' Characteristics

Karakteristik Studi	Grup	Estimate	Lower bound	Upper bound	Std. error	p-Value
School Level	Elementary School	**1.345**	0.537	2.153	0.412	0.001
	Junior High School	**1.327**	0.647	2.006	0.347	< 0.001
	Senior High School	-	-	-	-	-
Sampling	*Nonprobability sampling*	**0.332**	-0.161	0.826	0.252	NA
	Simple random sampling	**1.177**	0.650	1.704	0.269	< 0.001
	Purposive sampling	**1.148**	0.516	1.779	0.322	< 0.001
	Cluster Random Sampling	**2.375**	0.740	4.009	0.834	0.004
Sample Size	≥ 30	**1.100**	0.470	1.731	0.322	< 0.001
	< 30	**1.586**	0.594	2.578	0.506	0.002

Based on Table 6 above, it can be analyzed as follows:

1. Based on the educational level, an effect size of 1.345 was obtained for the elementary school (SD) level and 1.327 for the junior high school (SMP) level, both of which fall into the category of strong effects. Meanwhile, no effect size was available for the senior high school (SMA) level due to the absence of study data at that level. The p-values for SD and SMP levels were below 0.05, indicating that ethnomathematics-based learning significantly enhances students' conceptual understanding of mathematics at these levels. Although the effect sizes for SD and SMP are relatively similar, the value for the SD level is slightly higher. Thus, it can be inferred that ethnomathematics-based instruction is generally more effective at the elementary school level in enhancing students' conceptual understanding of mathematics.
2. Judging from sampling, the effect size in sampling using the Nonprobability sampling technique was 0.332 (Modest Effect), the effect size in the Simple random sampling technique was 1.177 (Strong Effect), the effect size in the Purposive sampling technique was 1.148 (Strong Effect), and the effect size in the Cluster Random Sampling technique was 2.375 (Strong Effect). Judging from the p-value, the non-probability sampling technique cannot determine the p-value (NA = Not available), possibly because there is only one research study, so the required data is still lacking. The p-values for Simple Random Sampling, Purposive Sampling, and Cluster Random Sampling techniques are all below 0.05, indicating that ethnomathematics-based learning significantly enhances students' conceptual understanding of mathematics across these sampling methods. Among them, Cluster Random Sampling yields the highest effect size. Hence, it can be concluded that the application of ethnomathematics-based learning is most effective when implemented using the Cluster Random Sampling technique.

Judging from the sample size, the effect size for a sample size of ≥ 30 students is 1.100 (Strong Effect), and the effect size for a sample size of < 30 students is 1.586 (Strong Effect). Judging from the p-value in both sample sizes, both have a p-value < 0.05, which means that Ethnomathematics Learning is effective, as seen from the students' ability to understand mathematical concepts at sample sizes ≥ 30 and < 30. In general, both sample sizes have a strong effect, but a sample size < 30 has a larger effect. These findings suggest that applying ethnomathematics-based instruction yields more favorable outcomes for students' conceptual understanding when the sample size is less than 30. This pattern is consistent with previous meta-analysis findings that found that education levels and design characteristics such as sampling and sample size greatly moderate the effects of ethnomathematical interventions (Pratama & Yelken, 2024; Sulistyowati & Sayuti, 2024). These findings imply that the context of the study, the representativeness of the participants, and the methodological quality greatly influence the magnitude of the effects obtained, so it must be considered both in the interpretation of the results and in the design of subsequent research.

Conclusions and Suggestions

Several limitations should be considered when interpreting the findings of this meta-analysis. Primarily, the scope was strictly confined to quantitative studies that provided all essential statistical data, namely, the mean, standard deviation, and sample size necessary for calculating the effect size. Consequently, this analysis only incorporates a small subset of particular quantitative research. It does not account for other quantitative study designs (such as purely descriptive or correlational research) that might be relevant but lack the required statistical triplets. Furthermore, this strict inclusion criterion entirely excluded qualitative studies, thus limiting a comprehensive and holistic understanding of the subject matter. Therefore, the conclusions drawn from this meta-analysis are inherently restricted to the quantifiable data extracted from the limited pool of eligible experimental and quasi-experimental research.

This meta-analytic investigation synthesized eight primary research studies conducted across Indonesia between 2018 and 2023 to evaluate the influence of ethnomathematics-based pedagogical approaches on students' understanding of mathematical concepts. Results demonstrated a combined effect size of 1.330, reflecting a robust magnitude that underscores the substantial, favorable impact of culturally-grounded mathematics instruction on learners' conceptual mastery. Among the examined investigations, five yielded robust effects, two produced moderate outcomes, and one generated modest results, collectively demonstrating that embedding cultural dimensions within mathematical pedagogy consistently strengthens learners' capacity to comprehend, interconnect, and utilize mathematical principles. Further examination of research characteristics revealed that ethnomathematics-oriented instruction is particularly beneficial in elementary education settings, especially when cluster random sampling methodologies are employed and participant groups consist of fewer than thirty individuals. Although funnel plot examination revealed slight asymmetry, the Fail-safe N assessment validated the resilience of these conclusions against potential publication bias, yielding an FSN coefficient of 412 that considerably surpasses the established threshold. These outcomes corroborate earlier scholarship highlighting the significance of culturally informed teaching practices in mathematics education, while providing empirical validation for incorporating ethnomathematical frameworks as a powerful pedagogical mechanism to cultivate enhanced conceptual comprehension, amplify learner participation, and generate more substantive educational experiences within mathematics classrooms.

Drawing on the findings of this meta-analytic study, several recommendations emerge for educational practitioners, policy makers, and subsequent researchers. Initially, mathematics educators and curriculum designers should deliberately incorporate localized cultural frameworks and ethnomathematical components into their instructional methodologies, with particular emphasis on elementary educational levels where this approach demonstrates optimal effectiveness. Such incorporation must transcend superficial cultural acknowledgments to authentically embed mathematical principles within students' experiential realities and cultural traditions. Subsequently, educator preparation initiatives ought to encompass professional growth opportunities centered on ethnomathematical pedagogy, furnishing teachers with the requisite competencies to recognize, examine, and apply culturally-situated mathematical practices throughout their instruction. Additionally, educational policy developers should consider establishing frameworks and supporting mechanisms that enable the deployment of ethnomathematics-based curricula across diverse educational environments, while respecting regional cultural heterogeneity.

Furthermore, forthcoming investigations must address the various constraints identified herein, encompassing the necessity for expanded research at secondary education levels, longitudinal explorations examining the sustained impacts of ethnomathematical instruction, and qualitative inquiries into the processes through which cultural incorporation strengthens conceptual mastery. Researchers should additionally probe the efficacy of ethnomathematics-based instruction across diverse mathematical content areas while examining possible moderating elements, including educator proficiency, instructional timeframes, and particular cultural contexts. Ultimately, considering the variability observed in the reviewed studies, subsequent meta-analytic endeavors would benefit from incorporating more extensive and heterogeneous collections of primary investigations, alongside the exploration of supplementary moderating variables that potentially affect ethnomathematics-based instructional effectiveness. By addressing these recommendations, the mathematics education scholarly community can move toward more culturally informed, equitable, and effective instructional practices that recognize students' varied backgrounds while cultivating a solid mathematical understanding.

Acknowledgements

I want to thank Pamulang University for supporting this research. I also want to express my gratitude to my colleague who helped me complete this writing despite the limitations.

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