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Meta-analysis Study of the effectiveness of the ethnomathematical approach on Students' Achievement

Endang Sulistyowati1*, Sugiman[2], Suminto A Sayuti3

[1-3]Universitas Negeri Yogyakarta, Indonesia,

ABSTRACT

The ethnomathematics approach is considered effective on students' mathematics learning achievement. Integrating culture and mathematics can provide meaningful mathematics learning so that it makes it easier for students to understand mathematical concepts. However, previous research investigating the e ectiveness of applying an ethnomathematics approach to mathematics learning achievement showed ambiguous results. erefore, this study will test the e ectiveness of the ethnomathematics approach to student achievement compared to conventional learning with a meta-analysis approach. is study analyzed 14 e ect sizes from 11 primary studies published in national and international journals that met the inclusion criteria. Data collection uses the online database Google Scholar, Education Resources Information Center (ERIC), Directory of Open Access (DOAJ), Springer publishing, AIP Proceedings, IOP Sciences, and Elsevier. e results of the analysis using the random-e ect approach obtained a combined e ect size of (d=1.35; p<0.05). is value is included in the very large e ect category. erefore, it can be concluded that the use of the ethnomathematics approach has a signi cant e ect on students' mathematics achievement when compared to conventional learning. e ndings of this meta-analysis show the consistency of the publication of research results regarding the e ectiveness of using the ethnomathematics approach to student achievement. is research can also be used as a basis for decision making by educators in improving the quality of learning mathematics in the classroom.

Keywords: students' achievement, ethnomatematics, e ect size, meta-analysis

INTRODUCTON

Mathematics is basically an abstract form of daily human life activities that students should be able to understand easily. However, there are still many students who still experience difficulties in learning mathematics. This is because the mathematics taught in schools is sometimes found to be di erent from the mathematical problems found in everyday life. This is in line with Rosa's statement in Andriyani and Kuntarto (2017) that there is a di erence between the mathematical knowledge that students acquire academically and informally. e discrepancy between the mathematical problems found in schools and the mathematics found in everyday life makes it di cult for students to relate the formal mathematical concepts to real-world problems. erefore, there are many students who are capable of operating mathematical calculations in class but nd it di cult to solve mathematical problems encountered in everyday life.

Educators need to apply a learning approach that can link mathematics learning with students' daily life activities, one of which is through their culture (Achor et al., 2009; Astutiningtyas et al., 2017; Sunzuma et al., 2021). Mathematics and culture are always connected in daily activities. Humans are essentially cultured beings; culture is deeply rooted in human life, while humans use mathematics to solve problems in their daily lives (D'Ambrosio, 2001; Putra & Mahmudah, 2017). erefore, culture becomes balanced when humans get the education to broaden their horizons universally so that humans do not forget culture, which is always rooted in their daily activities (Mora, 2012). For this purpose, ethnomathematics-based learning can be applied

Ethnomathematics studies aspects of mathematical culture in which the presentation is in the form of mathematical concepts in the school curriculum by linking student culture and everyday student experiences so that learning mathematics becomes more meaningful and students' understanding of mathematical concepts will be deeper (D'Ambrosio, 2001; D'Ambrosio & D' Ambrosio, 2013; Rosa & Orey, 2011; Ambrosio, 2018; Nur et al., 2020). Ethnomathematics is one of the tools needed to build a constructive and developmental inquiry-based mathematics learning process (Verner et al., 2019). In addition, Ethnomathematics can be used to enrich the mathematics curriculum such as helping students understand the concepts of mathematical abstract (Owens et al., 2015; Widada et al., 2019; Herawaty et al., 2019), strengthening problem-solving skills (Amit & Qouder, 2017;

Corresponding Author e-mail: dra.endang2015@student.uny.ac,id

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Nur et aal., 2020; Jurdak, 2016), developing spatial visual reasoning abilities (Owens & Muke, 2020), and creativity (D'Ambrosio, 2013).

Many studies have confirmed that ethnomathematics-based learning can increase students' learning achievement in mathematics (Abiam et al., 2016; James et al., 2021; Omere & Ogedengbe, 2022; Anthony, 2021; Hartinah et al., 2019; Umar et al., 2019; Imswatama & Lukman, 2018; Sunzuma et al., 2021; Nur et al., 2020; Maulana et al., 2020; Bahri et al., 2018). However, different results were found by Unodiaku (2013). Their findings show that ethnomathematics-based learning has no significant difference from conventional learning. Nevertheless, differences in the results of the research conducted can certainly provide conclusions that are not objective. One of the factors that affect the accuracy of the research is the sample size. Large samples produce precise results compared to small samples (Retnawati et al., 2018). Based on this problem, a research design is needed that can combine samples from previous studies so that the sample becomes wider and the research results become more accurate. One of the supporting research designs is meta-analysis.

A meta-analysis approach can be used to evaluate the results of previous studies to reach in-depth and accurate conclusions (Schmidt & Hunter, 2004; Retnawati et al., 2018; Tamur & Juandi, 2020). Meta-analysis is more objective than other review methods. Meta-analysis does not focus on the conclusions reached from various studies but instead focuses on data, such as performing operations on variables, the size of the effect size, and the sample size. To synthesize the research literature, the statistical meta-analysis uses the outcomes of studies with a similar effect size. This focus on the effect size of empirical findings is an advantage of meta-analysis compared to other literature review methods (Schmidt & Hunter, 2004; Retnawati et al., 2018).

Based on the literature search we have investigated so far, a meta-analytic study that examines the effectiveness of using an ethnomathematics approach has been carried out by Apriatni et al., (2022). However, the meta-analysis studies they carried out only synthesized local studies, while the studies in this meta-analysis synthesized international studies. This is done so that the conclusion can be general. For this reason, this study aims to assess the effectiveness of using an ethnomathematics approach to student achievement compared to traditional teaching. Furthermore, this meta-analytic study analyzes research published in national and international journals in the last ten years (2013-2022). Therefore, this research needs to be done to answer the ambiguous differences in the results of previous studies. In addition, the results of this study also provide more accurate results so that they can be used as a basis for policy-making to improve the quality of learning mathematics in the classroom.

Method

Research Design and Procedures

In this study, the effectiveness of the ethnomathematics approach to mathematics learning outcomes was analyzed using meta-analysis. A meta-analysis method is a quantitative approach that aims to systematically study and synthesize (combine) the quantitative estimation results from a number of previous studies that address the same research problem (Borenstein et al., 2009b). The procedure for this meta-analysis included: the determination of inclusion criteria, literature collection, literature screening, data extraction, and statistical analysis. Figure 1 visualizes the procedure in this meta-analysis.

Inclusion criteria

The inclusion criteria aimed to determine which studies are eligible for inclusion in a systematic review by meta-analysis. The inclusion criteria in this meta-analysis include: 1) The year of publication ranges from 2018 to 2022; 2) Articles must be written in English; 3) Research using experimental or quasi-experimental research methods; 4) There is at least one experimental group using an ethnomathematics approach and a comparison group as a control group with traditional teaching; 5) Research must report the mean, standard deviation and sample size of each experimental and control group; or sample size and t-value; or sample size and p-value; or the sample size by F-value.

Literature Collection

Relevant literature collection stage with inclusion criteria established using online databases such as Google Scholar, Education Resources Information Center (ERIC), Directory of Open Access (DOAJ), Springer publishing, AIP Proceedings, IOP Sciences, and Elsevier. The keywords used in the literature search are "ethnomathematics" AND students' achievement.

Literature Screening

Literature screening is used to assess whether the collected literature is appropriate or not to be used as material for meta-analysis. Literature screening was carried out concerning predetermined inclusion criteria. Screening was carried out

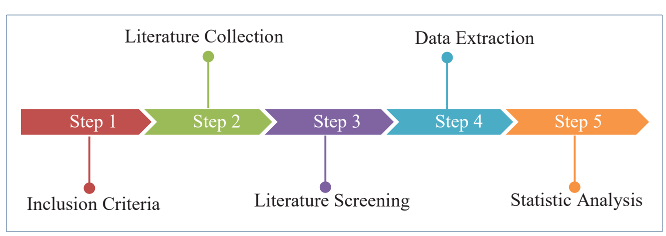

Fig. 1: Procedure Meta-Analysis

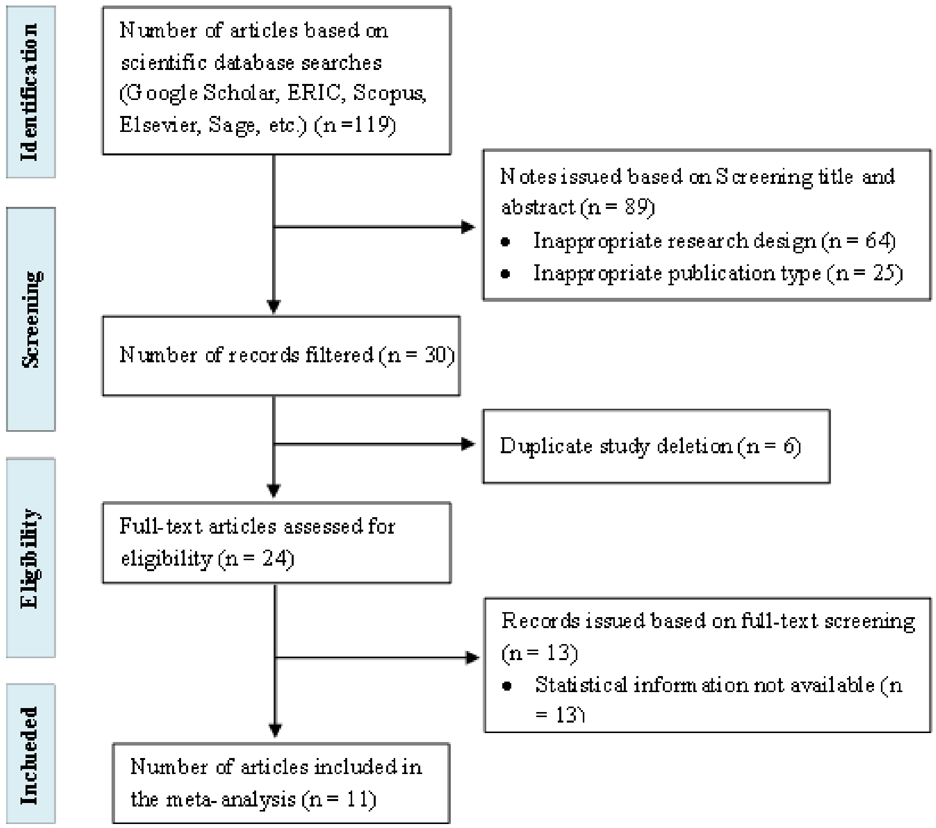

Fig. 2: Flow chart detailing the implementation of PRISMA.

through four stages which were guided by the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA), namely identification, screening, eligibility, and inclusion. The PRISMA protocol in this study is visualized in Figure 2.

The identification results resulted in 119 studies that were collected regarding the effect of implementing ethnomathematics-based learning. The screening phase resulted in primary studies, but 95 studies were excluded due to duplication and not meeting the inclusion criteria (study design and type of publication mismatch). Then, 13 studies were excluded due to inappropriate statistical and language information. The process resulted in 11 primary studies that met the eligibility criteria. However, some studies involved more than one control group, resulting in 14 effect sizes being analyzed.

Data Extraction

Data extraction is the activity of identifying quantitative data in the literature and then inputting it into a meta-analysis database. Quantitative data input in this meta-analysis study are the number of samples of the control group (Xc), the number of samples of the experimental group (Ne), the mean of the control group (Xc), the mean of the experimental group (Xe), the standard deviation of the control group (SDc), and Experimental group standard deviation (SDe). For more details, it can be seen in table 1..

Statistic Analysis

Statistical analysis in this study meta-analysis included: Calculating effect sizes for each study, performing heterogeneity tests, calculating effect summaries/combined effect sizes, analyzing moderator variables, and evaluating publication bias. Statistical analysis in this study used the OpenMEE application. This application has quite complete features for conducting meta-analytic studies. In addition, OpenMEE is also efficient in analyzing subgroups (moderator variables). Figure 3 presents the flow of statistical analysis in this meta-analysis study.

The meta-analysis focuses on effect size. The classification of the effect size of each study and the combined effect size in this meta-analysis refers to the classification of Cohen et al., (2019) which is shown in table 2.

Findings

This study aims to examine the effectiveness of using the ethnomathematics approach to students' mathematics achievement. Based on the results of these transformations, the effect size and variance of each effect size are obtained as presented in Table 3.

Table 1: Results of Primary Study Data Extraction

No	*Author*	*Nc*	*Xc*	*SDc*	*Ne*	*Xe*	*Sde*
1	Abiam et al., (2016)	202	43.22	9.78	202	54.56	11.99
2	James et al., (2021)	65	41.66	7.22	72	72.61	6.03
3	Unodiaku (2013)	150	12.79	1.28	156	11.37	1.15
4	Omere & Ogedengbe (2022)	200	41.95	16.06	200	65.03	19.73
5	Anthony (2021)	47	46.53	16.10	53	62.23	14.92
6	Hartinah et al., (2019)	26	42.46	0.20	25	57.64	0.20
7	Umar et al., (2019)	46	15.21	5.02	57	28.31	6.12
8	Imswatama & Lukman (2018) a	50	31.32	13.33	81	51.23	18.58
9	Imswatama & Lukman (2018) b	50	41.26	17.62	81	67.90	15.20
10	Sunzuma et al., (2021) a	40	39.90	14.20	50	53.90	19.00
11	Sunzuma et al., (2021) b	40	50.20	24.20	50	67.20	19.00
12	Nur et al., (2020)	30	60.30	13.94	30	69.17	17.13
13	Maulana et al., (2020)	26	67.95	7.09	23	77.61	7.83
14	Bahri et al., (2018)	31	78.00	0.79	31,0	80.13	5.63

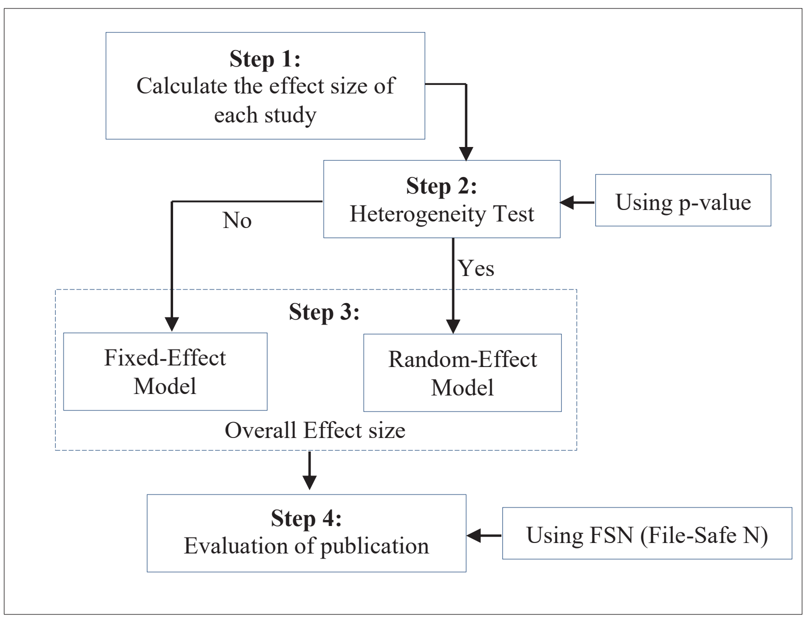

Fig. 3: Flowchart of Statistical Analysis in this Meta-Analysis

Based on table 4 above, out of a total of 14 effect sizes analyzed, the effect size values ranged from -1.17 to 4.65, with a 95% confidence level. Referring to the classification of Cohen et al. (2018), there is one effect size (n = 1) which is classified as a negligible effect, two effect sizes (n = 2) which are classified as moderate effects, seven effect sizes (n = 7) which are classified as large effects, and four effect size (n = 4) is classified as a very large effect. For more details, it can be seen in Figure 4..

Table 2. Categories of effect size (ES) groups using the Cohen interpretation

No	*Classification*	*Interval*
1	No Effect	0.00 < ES ≤ 0.19
2	Small Effect	0.19 < ES ≤ 0.49
3	Moderate Effect	0.49 < ES ≤ 0.79
4	Large Effect	0.79 < ES ≤ 1.29
5	Very Large Effect	ES > 1.29

Table 3: Summary of Effect size per Study

No	*Author*	*Effect Size*	*Varians*	*Category*
1	Abiam et al., (2016)	1.04	0.01	Large Effect
2	James et al., (2021)	4.65	0.11	Very Large Effect
3	Unodiaku & Sochima (2013)	-1.17	0.02	No Effect
4	Omere & Ogedengbe (2022)	1.28	0.01	Large Effect
5	Anthony & Omile (2021)	1.01	0.05	Large Effect
6	Hartinah et al., (2019)	3.44	0.19	Very Large Effect
7	Umar et al., (2019)	2.30	0.07	Very Large Effect
8	Imawatama & Lukman (2018) a	1.18	0.04	Large Effect
9	Imawatama & Lukman (2018) b	1.64	0.04	Very Large Effect
10	Sunzuma et al., (2021) a	0.82	0.05	Large Effect
11	Sunzuma et al., (2021) b	0.79	0.05	Large Effect
12	Nur et al., (2020)	0.56	0.07	Medium Effect
13	Maulana et al., (2020)	1.28	0.10	Large Effect
14	Bahri et al., (2018)	0.52	0.07	Medium Effect

Fig. 4: Comparison of effect size classifications between studies

Table 4. Heterogeneity test summary and combined effect sizes

Estimation Models	*k*	*Effect Size (d)*	*[95% CI]*	*P*	*Heterogeneity* *Q*	*p*	*I^2*
Random	14	1.35	[0.73, 1.97]	< 0.001	507.26	< 0.001	97.44%
Fixed	14	0.89	[0.79, 0.98]	< 0.001			

Note. k = the number of studies; CI = Confidence Interval; Df = degree of Freedom

Next, heterogeneity tests were investigated to select a suitable estimation model to calculate the combined effect size. Table 4 presents a summary of the heterogeneity tests and combined effect sizes.

The heterogeneity test results (see Table 5) show a Q value of 507.26. Since this value is greater than the chi-squared value (df = 13) and the p-value < 0.05, it can be concluded that the research conducted to calculate effect sizes was heterogeneous. The I^2 value was found to reach 97.44% reflecting high heterogeneity (Higgins et al., 2003). Because the studies used were heterogeneous, the overall effect size values were based on random effects models. Based on the random effect model, an effect size value of (d = 1.35; p <0.001). This effect size is included in the large effect category (Cohen et al., 2018). Thus, these results reveal that the use of the ethnomathematics approach greatly affects student achievement.

Table 5: File-Safe N (FSN)

	File Drawer Analysis *k*	*FSN*	*Target Significance*	*Observed Significance*
Rosenthal	15	1760	0.05	< 0.001

To prove that the meta-analysis conducted in this study reflects objectivity, publication bias was investigated. Table 6 presents a summary of the results of the publication bias test.

The results of the publication bias test (see Table 6) obtained an FSN value of 1760. This value is greater than 5k+10 = 110. This indicates that this meta-analytic study does not have a publication bias problem. Thus, the meta-analysis study was carried out objectively and scientifically justified.

Discussion

The analysis results showed that the combined effect size of the 14 effect sizes analyzed using the random-effect approach was (d = 1.35; p <0.001). These results indicate that the ethnomathematics approach is more effective in students' mathematics learning achievement than conventional learning. Furthermore, the effect size is in the very large effect category (Cohen et al., 2018). This also shows that the use of the ethnomathematics approach has a very large effect on mathematics learning achievement. The results of this study are in line with the meta-analysis research conducted by Apriatni et al., (2022), which shows that ethnomathematics-based learning is effective on problem-solving abilities of Indonesian students with a combined effect size obtained of 1.04 (large effect). Thus, learning with an ethnomathematics approach is highly recommended for mathematics teachers in the classroom.

In implementing ethnomathematics-based learning, the teacher tries to contextualize the material with real everyday situations, with existing local cultural values or practices (D'Ambrosio, 2001; Rosa & Orey, 2011). By linking mathematics learning as closely as possible to students' daily activities, students will feel that mathematics is a meaningful science in their lives, so mathematics is no longer considered a useless science. Thus, learning mathematics in the classroom cannot be separated from cultural phenomena in their local environment (Achor et al., 2009; Imswatama & Lukman, 2018; Sunzuma et al., 2021; D'Ambrosio & D'Ambrosio, 2013; Owens et al., 2015; Owens & Muke, 2020; Ambrosio, 2018; Nur et al., 2020; Zaenuri & Dwidayati, 2018).

Ethnomathematics helps to build awareness about the role of mathematical knowledge in society and the cultural context of mathematics (Rosa & Gavarrete, 2017). Students' success in learning mathematics can be realized if the subject matter of mathematics is related to real-life situations or students' experiences in everyday life (Correa et al., 2008). Experience can guide students' way of learning mathematics because experience is part of student life (Revina & Leung, 2019). Integrating culture into learning mathematics will make it easier for students to do abstractions to find concepts in mathematics (D'Ambrosio & Rosa, 2017; Zaenuri & Dwidayati, 2018; Owens et al., 2015; Widada et al., 2019; Herawaty et al. al., 2019). Ethnomathematics can also be used to enrich the mathematics curriculum such as strengthening problem-solving skills (Amit & Qouder, 2017; Nur et al., 2020; Jurdak, 2016; Apriatni et al., 2022), developing visual-spatial reasoning abilities (Owens & Muke, 2020), and creativity (D'Ambrosio & D'Ambrosio, 2013).

This meta-analysis study provides clear results that the different effect sizes between the variables of the ethnomathematics approach and students' mathematics achievement in terms of various literatures (some fall into the no-effect category to a very large effect) become clearer after a meta-analysis study is carried out, which is in the very large effect category. The results of the publication bias test show that this meta-analytic study does not have a publication bias problem, so this meta-analytic study is objective and scientifically justifiable. The results of this study are also expected to be the basis for policymaking so that the quality of mathematics learners in class can be optimized. In addition, the results of this study can also be used as a reference for comparing the application of the ethnomathematics approach to mathematics learning achievement in various places/locations or countries in addressing the importance of implementing ethnomathematics-based learning.

Conclusion

A meta-analysis of 11 primary studies examining the effect of the ethnomathematics approach on students' mathematics learning achievement showed that the combined effect size was 1.35. Based on the effect size classification by Cohen et al., 2018, this effect size is classified as a very large effect. Thus, it can be concluded that the implementation of the ethnomathematics approach has a major effect on student achievement compared to the conventional approach. Therefore, the findings of this meta-analysis provide more accurate results regarding the effectiveness of implementing an ethnomathematics approach to students' mathematics learning achievement.

Despite the reported validations, this meta-analytic study also has limitations. This study only analyzed 14 effect sizes from 11 main studies. Future research can carry out a meta-analysis by analyzing more studies to broaden and deepen the analysis. This study also did not analyze moderator variables. Future research can enrich the research results by analyzing moderator variables that are thought to influence the effect size of the ethnomathematics approach to students' mathematics achievement. In addition, the dependent variable being analyzed is mathematics learning achievement in general. Future research can measure the dependent variable specifically, for example, conceptual understanding, critical thinking skills, creativity, and others.

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