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THE INFLUENCE OF ETHNOMATHEMATICS BASED LEARNING ON MATHEMATICS PROBLEM-SOLVING ABILITY: A META-ANALYSIS

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Abstract

The introducer of ethnomathematics defined ethnomathematics as mathematics practised among identified cultural groups. Ethnomathematics positively impacts the learning process either as a Moderate or an approach to, for example, problem-solving ability. Previous researchers have carried out several studies on implementing ethnomathematical-based learning to improve students' problem-solving ability. However, the analysis shown is very varied, so it still raises doubts about the impact of learning using ethnomathematics on mathematical problem-solving abilities. This study aims to determine the correlation between ethnomathematical-based with students' problem-solving skills. This study uses meta-analysis research, which combines several experimental Studies that collate the effectuality of ethnomathematical-based learning and regular instruction on improving the mathematical problem-solving ability. Relevant studies were searched through e-resources from Perpusnas databases with the specified keywords. There are 106 studies obtained from the search query. Fourteen studies were selected according to the inclusion and exclusion criteria. Meta-Mar was used to determine the joined effect size by analysing the selected studies. This study shows that the joined effect size of applied ethnomathematical-based learning in improving mathematical problem-solving skills is 1,04 and was classified as a strong effect. Therefore, it is deduced that ethnomathematical-based learning relies on mathematical problem-solving abilities. Statistically, the implementation of ethnomathematics-based learning in improving mathematical problem-solving ability is also influenced by the study's characteristics at the level of education.

Keywords: a meta-analysis, ethnomathematics, mathematical problem-solving

1. Introduction

Learning is an active process carried out by teachers to develop the various potentials possessed by students (Hamidah, Junaedi, Mulyono, & Kusuma, 2021) to achieve a specific competence. The government has established several competencies for primary and secondary education levels in learning mathematics. After studying mathematics, it is expected that students can master one of the competencies or abilities that are pretty important, namely problem-solving skills or problem-solving skills (RI, 2016). In line with the government, the National Council for Teacher Mathematics (NCTM), an international mathematics education organisation, published a guideline called Principles and Standards for School Mathematics (PSSM) in 2020. PSSM contains standards regarding four main parts, one of which is content standards and process standards. Content standards describe five main content that students need to learn explicitly, while process standards highlight how to acquire and apply knowledge related to that content. NCTM writes that students need to master the four skills to learn the five main content in the guidelines. One of the essential skills mastered by students is problem-solving ability. Apart from being the goal of learning mathematics, problem-solving skills are also the primary tool for applying mathematics (NCTM, 2000).

In addition, NCTM also states that problem-solving is an essential ability that cannot be separated from mathematics. During the problem-solving process, students are encouraged to describe their way of thinking so that in the future, they can implement, develop, and determine the most appropriate strategy to find solutions to other problems in different contexts and situations. In addition, students with mathematical problem-solving abilities are also equipped with ways of thinking, habits, perseverance, curiosity, and self-confidence when facing different conditions (NCTM, 2000). Thus, problem-solving skills need to be given more attention, especially in learning mathematics, known as mathematical problem-solving. Problem-solving is the primary ability and needs to be developed through learning activities in the classroom.

Nevertheless, mathematics learning in schools has not been optimally oriented to developing students' potency. Mathematics learning tends to be oriented towards the application of routine procedures. In practice, students are asked to listen more to what the teacher says, then repeat to solve the questions as exemplified by the teacher. This activity takes place regularly with similar activities in learning activities.

Mathematics learning needs to be wrapped by the teacher into engaging learning and provide a learning experience for students. There are various exciting approaches and learning models that can be implemented in mathematics learning activities. Asstutiningtyas, for example, said that learning rooted in culture is an example of an exciting and fun mathematics learning approach (Astutiningtyas, Wulandari, & Farahsanti, 2017). Culture-based mathematics learning is known as ethnomathematics. Ethnomathematics presents mathematics learning that integrates it with values, norms, and products of human thought rooted in various people's lives. With ethnomathematical-based learning, it is hoped to foster a love for the homeland and students' culture, preserve the environment, and describe how mathematics benefits life (Zaenuri & Dwidayati, 2018).

Ethnomathematics can be viewed as an approach to learning mathematics to foster student motivation. With ethnomathematics, teachers try to contextualise or relate the subject matter with a real situation daily, with existing local cultural values or practices (Zaenuri & Dwidayati, 2018). This statement is in line with Frudental's statement in Zaenuri that "Mathematics must be connected to reality" or mathematics as close as possible to students' daily lives and related to situations experienced by students in everyday life (Zaenuri & Dwidayati, 2018). By bringing real-life situations into mathematics learning, students will feel that mathematics is a science that is close to their lives, so they no longer regard it as a science that has no use. Students can see how mathematics plays a role and benefits in life. Thus, cultural phenomena in the local environment are aspects that cannot be separated from learning mathematics in schools.

Uloko and Imoko in Astutiningtyas stated that ethnomathematical-based learning applied in mathematics learning in Japan and China succeeded in bringing the country into a developed country (Astutiningtyas et al., 2017). For example, in Japan, when studying mathematics, students face a real problem relevant to their daily lives and adapt to the surrounding environment to be solved it according to their mindset (Hamidah et al., 2021). In line with Japan, China conducts mathematics learning by including character education by utilising local culture since elementary school. China is known as a country with solid independence and implements an education system with high standards so that technological products produced by China can be enjoyed by consumers around the world (Zaenuri & Dwidayati, 2018).

Ethnomathematics in learning mathematics, according to Schoenfield in Zaenuri, can be used to 1) encourage students to think that mathematics is an inseparable part of everyday life; 2) improve the ability to find relationships between mathematical concepts in various contexts through mathematical problem-solving activities both individually and in groups (Zaenuri & Dwidayati, 2018). This statement shows a positive relationship between ethnomathematics and mathematical problem-solving ability.

Many studies have been carried out on the implementation of ethnomathematical-based learning, especially to analyse the influence of its implementation on increasing mathematical problem-solving abilities. Several studies have shown such results. Asstutiningtyas' research shows that the mastery of mathematics can be improved through learning with ethnomathematics (Astutiningtyas et al., 2017). In addition, according to Astuningtyas, the mathematical problem-solving ability can be improved by involving ethnomathematics. Research conducted by Nofitasari and Zaenuri Mastur showed similar results. They wanted to know whether the peer tutoring model with ethnomathematical bases affected students' problem-solving abilities. They limit the subject of mathematics to rectangular material. Nofitasari and Zaenuri Mastur mention a positive and significant relationship between the learning model and problem-solving abilities and conclude that problem-solving abilities can be improved by implementing peer tutoring models with ethnomathematical bases in learning mathematics (Nofitasari & Zaenuri Mastur, 2016). Based on the results of the above studies, we can say that learning mathematics using an ethnomathematical-based approach will improve mathematical problem-solving abilities. Nisrina showed different results from most research results with similar topics. The results of his research show that ethnomathematics does not have a significant effect on students' problem solving skilss (Nisrina, Agustin, & Mahmudah, 2021). However, the analysis shown is very varied, so it still raises doubts about the impact of learning using ethnomathematics on mathematical problem-solving abilities. This result certainly creates confusion among teachers whether or not to use an ethnomathematical approach in learning mathematics.

For this reason, it is necessary to analyse, combine, and synthesise study results related to the application of ethnomathematical-based learning to describe in depth how much influence this learning has on increasing mathematical problem-solving abilities compared with the application of the ordinary learning. Yustinaningrum re-analyse the effect of the problem-based learning model on students' mathematical problem solving abilities (Yustinaningrum, 2021). Priska and Mawardi find the effect of the problem solving learning model and the problem posing learning model in improving critical thinking skills (Priska & Mawardi, 2021). There are also several other meta-analytical studies aimed at analyzing the themes of problem solving, critical thinking, and ethnomathematics separately such as Safaria et al. (2021), Nugroho et al. (2020), and Aisyah (2022). However, no meta-analysis has been found that specifically aims to analyze the relationship between ethnomatics-based learning and problem-solving abilities. In addition, several research backgrounds also need to be described, such as the year, level of education of the subjects involved, many samples, publication sources, and learning models. This description is intended to find out what characteristics allow the application of ethnomathematical-based learning to be better and have a greater influence on increasing mathematical problem-solving abilities.

2. Method

This study uses meta-analysis. This study follows a similar stages, namely determine inclusion criteria; literature search and data coding; evaluate study quality; analysis statistic and build an interpretation. In addition, this approach was also chosen because the researcher attempted to analyse the measure given by each study regarding the magnitude of the influence of a variable on another variable. For this purpose, a meta-analysis technique is used. The meta-analysis technique is an analytical technique that combines the results of the corresponding Studies to be analysed statistically to find the combined effect of each study used (Cohen, Manion, & Morrison, 2007).

The procedures in this study are: 1) the formulation of the research problem; 2) search of relevant literature; 3) study coding; 4) statistical analysis by calculating effect size; 5) withdrawal of interpretation of results and examination of publication bias; 6) preparation of reports/ conclusions (Valentine, Hedges, & Cooper, 2009).

In the first step, the formulation of the research problem is how much influence the application of ethnomathematical-based learning has on mathematical problem-solving abilities. The next step is to search the relevant literature by first determining the inclusion criteria to confirm the literature's specifications.

Population and Sample

The studies involved in the meta-analysis are the results of Studies that lie in the researcher's criteria. The meta-analysis in this study was conducted by combining and analysing several studies that have been published in journals or proceedings with the same theme, namely the application of ethnomathematical-based learning and its effect on mathematical problem-solving abilities.

The unit of analysis of ethnomathematical themes in mathematics learning is articles obtained from the digital library owned by National Library with publication dates starting from January 2015 to June 2022 or for the last 8 years, finding a total of 106 articles as the population of this study. The search criteria are limited to journal articles with full text availability.

The number of articles obtained was so large, the decision of the number of samples used in this study was carried out through a screening process (inclusion and exclusion), and a procedure for assessing the quality and relevance of 106 articles using the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) developed by Moher, Liberati, Tetzlaff, Altman, and The PRISMA Group (Moher, Liberati, Tetzlaff, & Altman, 2009).

Inclusion and Exclusion Criteria

All literature obtained in the initial search was examined and selected to be selected as the primary study using the inclusion and exclusion criteria. Inclusion criteria in this study are:

a. Academic article journal
b. Whole country
c. Education fields
d. All publications from January 2015 to June 2022
e. The type of research is limited to semi-experimental design with unequal control group experimental design, post-test control group design only, and one-group design with pretest-posttest.
f. The subjects involved are elementary, junior and senior high school students and higher education at the Strata 1 level

The literature obtained was selected based on the inclusion criteria that have been set. While the exclusion criteria were adopted from Priola's research (2016), are:

a. The title is irrelevant
b. No full text available
c. Removal of duplicate articles
d. Abstract is irrelevant
e. Non-empirical research
f. Required data (sample size, average, and standard deviation) not available.

The Studies were searched among the theme of applying ethnomathematical-based learning to mathematical problem solving through https://e-resoureces.perpusnas.go.id by the keywords: "ethnomathematics", "ethnomathematics problem solving", "ethnomathematics learning problem solving", "ethnomathematics problem solving", "ethnomathematics problem solving", "ethnomathematics learning, problem-solving". Based on the inclusion criteria, there were 106 articles obtained from this searching. Next is to select, which article will be excluded from this result. Based on the exclusion criteria, there were only 14 articles remain while the others are excluded from the result. These 14 articles were then used as primary study sources.

The source of the primary study is then coded. The coding is done through manual coding instruments using Microsoft Excel. The coding process was carried out by writing down the information involved in the analysis process: study code, author's name, year of publication, title, source, research design, statistical information (many samples, mean, and standard deviation of both groups). The publication period is divided into four categories: 1) 2015 to 2016; 2) 2017 to 2018; 3) 2019 to 2020, and 4) 2021 to 2022. Furthermore, based on the founded articles, the education level categories are made into four classifications: basic or elementary education level, junior secondary education level or SMP/MTS, upper secondary education level or SMA/MA, and higher education level for the S1 program. The number of samples is classified into samples with a size of less than or equal to 30 and more than or equal to 31.

Statistical analysis was performed first by calculating the Effect Size (ES). ES is a measure that describes how much influence a variable, namely the implementation of ethnomathematical-based learning, has on other variables, namely the ability to solve mathematical problems. The ES calculation used in this study uses Hedges statistics based on the Standardised Mean Difference (SMD) (Retnawati, Apino, Kartianom, Djidu, & Anazifa, 2018). Therefore, the ES calculation was performed by comparing the mean and standard deviation of the two groups (experimental and control groups) with various outcome measures. The ES in this meta-analysis was interpreted according to the classification of Cohen et al. (2007), which is presented in Table 1.

Table 1. . The ES Interpretation

Effect Size (ES)	Interpretation
0 – 0,20	Weak Effect
0,21 – 0,50	Modest Effect
0,51 – 1,00	Moderate Effect
>1,00	Strong Effect

After calculating the ES, the next step is to test for homogeneity. Homogeneity testing is intended to determine the analytical estimation model (Retnawati et al., 2018). Determination of the model is done by checking the *p-value* on the Q-statistics. This test's null hypothesis (H_0) is that the primary study ES used in the analysis is homogeneous. If the *p-value* is below 0.05, the null hypothesis is rejected, meaning the ES is heterogeneous. Therefore, it was determined that the random-effects model as the estimation model was used. On the other hand, if the *p-value* is above 0.05, the null hypothesis is accepted, which means the ES is homogeneous, so it is determined that the fixed effects model is the estimation model used (Retnawati et al., 2018).

The next step is publication bias testing. This study uses several published Studies for analysis. Publication bias testing is intended to ensure that these Studies are representative of all other Studies examining the same issue. In addition, this test was also carried out to prevent the suggestion that the Studies included in this study were only Studies with significant ES and did not include Studies with low ES, thereby creating a target research bias due to concerns that the meta-analysis might overestimate the actual ES. Publication bias testing was carried out using a funnel plot and Rosenthal's File-N Safe (FNS) (Retnawati et al., 2018). This study used funnel plots as the first step in testing publication bias. To help determine whether there is a possibility of publication bias, the researcher used FNS Rosenthal. The FNS Rosental will be used if the ES is distributed asymmetrically or not completely symmetrically distributed (Tamur, Juandi, & Kusumah, 2020). If $\frac{FNS}{5k+10} > 1$, where k is the number of primary studies used, the research is not influenced or free from publication bias (Paloloang, Juandi, Tamur, Paloloang, & Adem, 2020). If there is no publication bias, then the next stage of meta-analysis can be continued.

The last step is to produce a report on the results or draw a conclusion based on the hypothesis testing. The null hypothesis in this test is that there is no significant effect of applying ethnomathematical-based learning on increasing mathematical problem-solving abilities compared to ordinary learning models. For the fixed effect estimation model, hypothesis testing can be done by examining the *p-value* (Retnawati et al., 2018). If the *p-value* is above 0.05, the null hypothesis is accepted, and vice versa. For the random effect estimation model, which means that there are differences in the characteristics of the Studies involved, an analysis of the characteristics of certain Studies is carried out, and then draws conclusions based on the results of the analysis of these characteristics (Borenstein, Hedges, Higgins, & Rothstein, 2010).

3. Result and Discussion

The main objective of this research is to describe the effect of learning by applying ethnomathematics to problem-solving abilities through a combined ES analysis of the Studies used. The list of studies that meet the inclusion criteria is presented in the following table.

Table 2. Studies used in the analysis

Study No	Name of Journal/ Proceeding & URL
Study 1	Unnes Journal of Mathematics Education URL: https://bit.ly/37Q4yWJ
Study 2	JRAMathEdu (*Journal of Research and Advances in Mathematics Education*) URL: https://bit.ly/3xZRaKa
Study 3	Jurnal Pendidikan Matematika Universitas Lampung URL: https://bit.ly/3vQE8My
Study 4	SENPIKA II (Seminar Nasional Pendidikan Matematika) URL: https://bit.ly/3vQE6nU
Study 5	Unnes Journal of Mathematics Education URL: https://bit.ly/3vYgKgi
Study 6	PRISMA, Prosiding Seminar Nasional Matematika URL: https://bit.ly/3rYLQmO
Study 7	Jurnal Pendidikan Matematika Raflesia URL: https://bit.ly/36YEJmR
Study 8	Jurnal Pendidikan Matematika Raflesia URL: https://bit.ly/3y70EUh
Study 9	Unnes Journal of Mathematics Education URL: https://bit.ly/37T5Ekz
Study 10	JNPM (Jurnal Nasional Pendidikan Matematika) URL: https://bit.ly/3EYqif6
Study 11	Unnes Journal of Mathematics Education URL: https://bit.ly/3MFo2vS
Study 12	Journal of Physics: Conference Series (JPCS) URL: https://bit.ly/3vV2nsK
Study 13	Unnes Journal of Mathematics Education URL: https://bit.ly/3y16KFv

Study 14	Jurnal Math Educator Nusantara (JMEN): Wahana Publikasi Karya Tulis Ilmiah di Bidang Pendidikan Matematika URL: https://bit.ly/3Lxbx5E

The tool used to calculate the primary Study-Study ES, standard error, and confidence interval of each study is Meta-Mar Free Online – Meta-Analysis Service with Hedges statistics based on Standardized Mean Difference (SMD) presented in the following table.

Table 3. Primary study coding results

No	Authors	ES	ES interpretation	SE	Confidence Intervals	
					Lower Bound	Upper Bound
1	Prabawa & Zaenuri, 2017	1,059	Strong	0,282	0,507	1,612
2	Nur et. al, 2020	0,561	Moderate	0,260	0,051	1,070
3	Kurniawati et. al, 2018	3,220	Strong	0,391	2,452	3,987
4	Hidayati & Restapaty, 2019	0,468	Modest	0,247	-0,016	0,951
5	Nofitasari et. al, 2016	0,927	Moderate	0,262	0,413	1,441
6	Yunitasari & Zaenuri, 2020	1,250	Strong	0,277	0,707	1,794
7	Yanti et. al, 2018	1,277	Strong	0,254	0,779	1,775
8	Lubis & Widada, 2020	1,415	Strong	0,269	0,889	1,942
9	Maulana et. al, 2020	1,277	Strong	0,310	0,669	1,884
10	Aprilyani & Hakim, 2020	0,846	Moderate	0,262	0,333	1,360
11	Bahri et. al, 2018	0,523	Moderate	0,255	0,023	1,023
12	Irawan et. al, 2018	0,942	Moderate	0,246	0,459	1,424
13	Abdullah, Z, & H, 2015	0,454	Modest	0,254	-0,044	0,952
14	Astutiningtyas et. al, 2017	0,824	Moderate	0,289	0,258	1,390

Based on the table above, each of the 14 primary studies has an ES that varies from 0.454 to 3,220. Based on Cohen (2007), data obtained that six studies have strong ES, which means that ethnomathematical-based learning in these six studies strongly influences mathematical problem-solving abilities. In addition, six studies have Moderate ES, which means that ethnomathematical-based learning in these six studies has a Modest effect on mathematical problem-solving abilities. Also, two studies have Modest ES, which means that ethnomathematical-based learning has a modest effect on mathematical problem-solving abilities.

The above result indicates that the study was not influenced or free from publication bias. It means there is no publication bias; in other words, the studies involved in the research are representations of other similar studies so that there is no need for additional studies to be added to the study as a result of the absence of publication bias (Paloloang et al., 2020).

Next is to calculate the combined ES of all primary studies involved in the study. Prior to that, the estimation model was first determined through homogeneity testing. The information needed for the homogeneity test is as follows.

Table 4. ES Distribution Homogeneity Test

	Heterogeneity		
Chi-Square	***df***	***P-Value***	***I-Square***
53,68	13	0,00	75,8

Table 4 shows that the *p-value* = 0.00 which means that the p-value <0.05. Therefore, the null hypothesis in this test is rejected, which means that the ES is heterogeneous. Therefore, an estimation model in a random-effects model was used to determine the combined ES. Furthermore, the funnel plot is presented in the following figure.

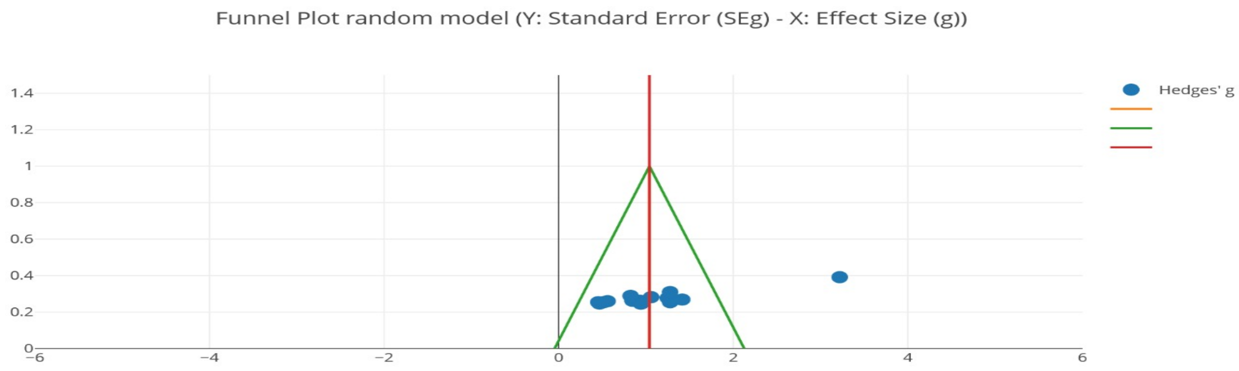

Figure 1. *Funnel Plot*

Based on Figure 1, it is found that the ES distribution is not completely symmetrical around the vertical line. Therefore, detecting it can be done using Rosenthal's Fail-N Safe (FNS) from 14 studied studies. From the calculation, it was found that the FNS value = 994.55. With *k* being the number of studies used, we obtain $\frac{FNS}{5k+10} = \frac{994,55}{5(14)+10} = \frac{994,55}{80} = 12,43 > 1$. Table 5 presents the calculation for the two estimation models. The main information displayed in this table is ES and *p-value.*

Table 5. ES value based on estimation 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	14	0,97	0,072	0,827	1,11	13,408	0,00
Random Effect Model	14	1,04	0,148	0,747	1,326	7,02	0,00

Using the random effect estimation model shows that the p-value = 0.00 or the p-value is less than 0.05. Based on the criteria for testing the hypothesis, it can be said that overall, the ethnomathematical-based learning model has a significant effect on mathematical problem-solving abilities when compared to the ordinary learning model. This conclusion is in line with other studies, such as the research conducted by Oktovianus. Oktovianus conducted a study to determine whether or not the application of ethnomathematics-based mathematics learning affected student learning outcomes. Oktovianus concluded that ethnomathematics-based mathematics learning has a significant influence and is also more effective in improving learning outcomes when compared to other groups of students who apply the usual learning model (Oktovianus, 2021). Based on this result, it can be seen that ethnomathematics-based learning mathematics is an alternative for teachers to improve student learning outcomes, especially in learning mathematics.

In addition, based on the random-effects model with a 95% confidence level, the combined ES of the entire study was 1.04, which, based on the interpretation of Cohen et al. (2007), this ES was classified as a strong effect. Thus, it can be said that the ethnomathematical-based learning model has a strong effect on increasing mathematical problem-solving abilities compared to ordinary learning models.

According to Coe (2002), the combined ES of 1.04 indicates that students' mathematical problem-solving ability in the experimental group is higher than the mathematical problem-solving ability of 84% of students in the control group. In the previous homogeneity test, information was obtained that the primary ES Study data followed a heterogeneous distribution. The next step is to analyse the characteristics of the study, which are suspected to be the cause of the inhomogeneity of the ES data on mathematical problem-solving abilities. For this reason, an analysis of the characteristics of the study was carried out, namely: year of research, level of research, sample size, and learning model. The analysis results of these characteristics can be seen in the following table.

Table 6. Study Characteristics Analysis Results

Study Characteristics	Kategori	n	*Hedge's g*	*Test of null (2-Tail)*		Batas Bawah	Batas Atas
				Z-value	*p-value*		
Publication year	2015 – 2016	2	0,69	2,901	0,0037	0,223	1,15
	2017 – 2018	6	0,97	8,161	0,0000	0,740	1,209
	2019 – 2020	5	1,03	5,67	0,0000	0,677	1,392
	2021 – 2022	1	1,06	3,623	0,000132	0,517	1,603
Educational level	SD	2	1,08	5,644	0,0000	0,703	1,451
	SMP/MTS	9	0,78	7,541	0,0000	0,577	0,982
	SMA/MA	2	1,37	7,386	0,0000	1,005	1,732
	Higher Education	1	0,82	2,853	0,004325	0,258	1,39
Sample Size	30 or below	5	0,97	7,203	0,0000	0,703	1,228
	31 or above	9	0,9	7,286	0,0000	0,656	1,138
Learning Model	Problem Based Learning	5	0,77	4,154	3.3e-05	0,408	1,138
	Realistic Mathematics	3	1,21	8,203	0,0000	0,924	1,504
	Project-Based Learning	1	1,06	3,758	0,000171	0,507	1,612
	Contextual Learning	1	0,56	2,157	0,031027	0,051	1,070
	Peer Tutor	1	0,93	3,536	0,000407	0,413	1,441
	Inquiry	1	1,19	4,252	2.1e-05	0,643	1,742
	Assurance, Relevance, Interest, Assessment, Satisfaction Learning	1	0,85	3,229	0,001242	0,333	1,360

From the table above, for the characteristics of the study in the form of the year of research, it can be seen that the study conducted in 2015 – 2016 had an ES of 0.69, which was classified as a Modest effect, equivalent to the study in 2017 – 2018 which had an ES of 0.97 which was also classified as the Moderate effect. The 2019 – 2020 and 2021 – 2022 show ES of 1.03 and 1.06, respectively, classified as strong effects. Based on the characteristics of the publication year, it can be seen that the *p-value* is less than 0.05, which indicates that each group in the research year has a significant influence on the application of ethnomathematical-based learning to improve mathematical problem-solving abilities. By giving attention to the lower and upper limits of each year group, it is found that there is a wedge between the lower and upper limit intervals; this indicates that the effect of each year group is the same. It means that all groups of research years have the same effect on applying ethnomathematical-based learning to mathematical problem-solving abilities with Moderate and strong ES categories. This result is in line with research conducted by (Nugroho et al., 2020) which showed that the environmental-based learning ES (ethnomathematics) studied from 2016 to 2020 were in the Moderate and strong categories.

For the educational level, it can be seen that the study conducted at the elementary level gave an ES of 1.08, which was classified as a strong effect, barely better than the study at the high school level, which gave an ES of 1.37, which was classified as a strong effect. The junior high school level study gave an ES of 0.78 which was classified as a Modest effect, similar to a study conducted in universities with an ES of 0.82, which was classified as a Modest effect. Based on the characteristics of the education level study, a *p-value* of less than 0.05 was obtained, indicating that each level of education significantly influences applying ethnomathematical-based learning to improve mathematical problem-solving abilities. By paying attention to the upper and lower bound intervals for each level of education starting from Elementary School (0.703 – 1.451), Junior High School (0.577 – 0.982), Senior High School (1.005 – 1.732), and Higher Education (0.258 – 1.39) information are obtained that there is no interval intersection. The lower and upper bound values are at the junior and senior high school levels. It shows that junior and senior high school education levels have a different effect on applying ethnomathematical-based learning models to mathematical problem-solving abilities. High school education has a more effective influence than junior high school level. It means that the application of ethnomathematical-based learning in improving mathematical problem-solving abilities is influenced by the characteristics of the education level study. These results show a difference from the research conducted by Tungga (2021), which states that the level of education studied, namely the junior and senior high school levels, in the application of ethnomathematics has the same effect on student learning outcomes that fall into the category of strong effects.

For sample size characteristics, it appears that studies with a sample size of below or equal to 30 people have an ES of 0.97, and those with a sample size of above or equal to 31 people have an ES of 0.90, or both based on sample size, both are in the Modest effect category. Furthermore, the characteristics of the study sample size have a *p-value* of less than 0.05, which indicates that each sample size has a significant effect on the application of ethnomathematical-based learning to improve mathematical problem-solving abilities. Since the lower and upper bound intervals in studies with a sample size of 30 or below (0.703 – 1.228) as well as in studies with a sample size of 31 or above (0.656 – 1.138), there is a wedge between the lower and upper limit intervals in both study groups. Thus, the two-sample size groups have the same effect on applying ethnomathematical-based learning to mathematical problem-solving abilities.

For the learning model characteristics, it can be seen that the ES Study, which was carried out by applying an ethnomathematics-based realistic learning model, was 1.21, and the Project-Based Learning model was 1.06. Both are in the category of strong effects. Meanwhile, Peer Tutor Learning provides an ES of 0.93, barely better than the ES of Assurance, Relevance, Interest, Assessment, Satisfaction learning models of 0.85, which are in Moderate effect. In addition, the application of Problem Based Learning and ethnomathematical-based Contextual Learning models gave ES of 0.77 and 0.56, respectively, which were in the same category and had a Moderate effect on mathematical problem-solving abilities. Based on the characteristics of the learning model, the p-value is less than 0.05, which indicates that each type of learning model that applies ethnomathematical-based learning has a significant effect on increasing mathematical problem-solving abilities. By paying attention to the lower and upper limits of each study characteristic based on the learning model, information is obtained that the implementation of the Project-Based Learning model is in the interval 0.408 – 1.138; the application of the Realistic Mathematics model is in the interval 0.924 – 1.504; Project-Based Learning model is in the interval 0,507 – 1,612; Contextual Learning model is in the interval 0.05 – 1.070; Peer Tutor models are in the interval 0.413 – 1.441; Inquiry model is in the interval 0.643 – 1.742; and the Assurance, Relevance, Interest, Assessment, Satisfaction learning model is in the interval 0.333 – 1.360. It was found that there is a wedge between the upper limit interval and the limit on the characteristics of the study based on the applied learning model. It shows that the effect of the learning model is the same, and ethnomathematical-based learning models have the same effect on mathematical problem-solving abilities with Moderate and strong ES categories.

Based on the findings above, it can be stated that the ethnomathematical-based learning model can be applied as an alternative learning approach to improve mathematical problem-solving abilities, both at a sample size of 30 people or below or 31 people or above. Ethnomathematics-based learning models suggested to improve mathematical problem-solving skills include Project-Based Learning models, Realistic Mathematics learning models, Project Based Learning models, Contextual Learning models, Peer Tutor models, inquiry models, and Assurance, Relevance, Interest, Assessment learning models. , Satisfaction. Based on the characteristics of the education level study, it was found that the junior and senior high school education levels were the cause of the inhomogeneity of the combined ES in the influence of the application of ethnomathematical-based learning on students' mathematical solving abilities. It means that the application of ethnomathematical-based learning in improving mathematical problem-solving abilities is influenced by the characteristics of the level of education. The magnitude of the ES obtained for each study characteristic shows that ethnomathematical-based learning will have the most significant impact when applied to a realistic mathematics learning model at the high school level.

4. Conclusion

The meta-analysis results of 14 primary studies that discuss the effect of applying ethnomathematical-based learning on mathematical problem-solving abilities show that the combined ES of the study is 1.04. Based on Cohen et al. (2007) classification, this figure is included in the range of strong effect sizes. This means that applying the ethnomathematics-based learning model has a strong influence on increasing mathematical problem-solving abilities. Besides being more artificial, the effect given is also more effective when compared to the application of ordinary learning models. By judging the characteristics of the primary study, it can be concluded that junior and senior high school education levels have different effects on mathematical problem-solving abilities. In other words, the application of ethnomathematical-based learning in improving mathematical problem-solving abilities is influenced by the characteristics of the level of education. Various findings in this meta-analysis conclude that mathematical problem-solving abilities can be improved by applying one of the alternative models in mathematics learning, namely the ethnomathematical-based learning model.

Furthermore, it is recommended that further researchers use other, more diverse study characteristics to get a more in-depth study and find other more exciting things.

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