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META-ANALYSIS STUDY: EFFECT OF REALISTIC MATHEMATICS EDUCATION (RME) APPROACH ON STUDENT'S MATHEMATICAL LITERACY SKILL

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Abstract

A comprehensive review about approach to Realistic Mathematics Education (RME) impact on mathematical literacy abilities has not been studied extensively, consequently, many teachers are unaware of the advantages of this method for students. This meta-analysis research was carried out to analyze the overall effect size of applying the RME approach to mathematical literacy skills. Empirical data obtained from Google Scholar, Semantic Scholar, URL link directly. The outcomes of the search are nine articles published between 2016 and 2021. In accordance with the inclusion criteria, nine items were qualified for analysis. Comprehensive Meta-Analysis (CMA) software is used in the analysis tool, and a random estimation model. The results revealed that the study's overall effect size was 1.051. These findings suggest that the application of the RME approach has a strong effect on students' mathematical literacy abilities. The moderator variables were examined, and it was discovered that the RME approach was effective by considering student demographics, but not at the educational level. This meta-analysis study advises Indonesian math teachers that the application of RME in increasing students' mathematical literacy should be used more frequently, especially in elementary schools.

Keywords: Mathematical literacy skill; meta-analysis study; realistic mathematics education approach

Abstrak

Ulasan komprehensif tentang efek dari pendekatan Realistic Mathematics Education (RME) pada kemampuan literasi matematis belum banyak dipelajari secara ekstensif, menyebabkan banyak guru yang belum menyadari manfaat dari pendekatan ini untuk siswa. Studi meta-analisis ini dilakukan untuk menganalisis ukuran efek keseluruhan penerapan pendekatan RME terhadap kemampuan literasi matematis. Data empiris diperoleh dari Google Scholar, Semantic Scholar, Link URL secara langsung. Hasil pencarian menemukan sembilan artikel diterbitkan antara 2016 dan 2021. Menurut kriteria inklusi, sembilan item memenuhi syarat untuk analisis. Alat analisis menggunakan perangkat lunak Comprehensive Meta-Analysis (CMA), dan model estimasi random. Hasil penelitian mengungkapkan bahwa ukuran efek keseluruhan dari penelitian ini adalah 1,051. Hasil ini menunjukkan bahwa penerapan pendekatan RME memiliki efek kuat pada kemampuan literasi matematis siswa. Analisis variabel moderator mengungkapkan bahwa Pendekatan RME pelaksanaannya efektif dengan mempertimbangkan demografi siswa, namun tidak pada tingkat pendidikan. Studi meta-analisis ini merekomendasikan kepada guru matematika Indonesia agar penerapan RME dalam meningkatkan literasi matematika siswa harus lebih diterapkan terutama di sekolah dasar.

***Kata kunci**: Kemampuan literasi matematis; pendekatan realistic mathematics education; studi meta-analisis.*

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INTRODUCTION

In the 21st century, life is increasingly complex, marked by the emergence of various challenges and demands in various fields. Each individual needs to master multiple abilities and skills. Mathematical literacy needs to be learned (Fajaruddin Atsnan, Muh; Yulia Gazali, 2019; Janah et al., 2019; Masjaya & Wardono, 2018). Mathematical literacy skills are also a different demand in implementing the 2013 Curriculum. So increasing mathematical literacy skills is one of the priorities for learning mathematics at the school level.

Many pedagogical approaches can facilitate students' literacy skills. One of them is RME approach. The RME approach is learning where students start from situations and problems in the "real" world and reinvention mathematical ideas and concepts with guidance and direction from the teacher (Merina et al., 2019; Zaini & Marsigit, 2014). Meta-analysis is a quantitative research technique that combines the findings of previous studies to produce integrated data on the strength of correlation, influence, and relationships between variables (Cumming, 2012), which considers effect size as a measurement factor (Cleophas & Zwinderman, 2017).

Research of meta-analysis has been conducted on RME effect implementation on some mathematical skills. For example, a study conducted by (Juandi et al., 2022) examined the RME approach in the last two decades by providing research results. This demonstrates that using RME has a significant positive effect on students' mathematical abilities. Then research on the influence of RME on students' critical thinking skills was carried out (Shoffa, 2022; Utami & Indarini, 2021), with the results of research in applying the RME approach to critical thinking skills that have a moderate effect. Meta-analysis research related to mathematical literacy skills that have been carried out is still limited; for example, a study carried out by (Paloloang et al., 2020) examined the impact of the PBL learning model on students' mathematical literacy. According to the findings of the study, the overall effect size of the application of PBL on students' mathematical literacy skills is quite effective. So, this study focuses on applying the RME approach to students' mathematical literacy skills with moderator variables of education level and student demographics.

Numerous studies have attempted to determine if using RME significantly enhances students' mathematical literacy abilities in Indonesia. The results of this study vary. Some researchers say that RME has a positive effect (Handun et al., 2020; Herutomo & Masrianingsih, 2021; Kusuma et al., 2016; Nuraeni & Umbara, 2018). Of course, the heterogeneity of the results raises new problems, mainly because of references to people who believe RME affects students' mathematical literacy. Educational policymakers require extensive and comprehensive information to establish the framework for implementing education in Indonesia, and mathematics teachers require this information to select appropriate alternative learning models to support mathematics learning literacy in the classroom. So, this issue suggests undertaking a more thorough study to analyze all the findings' variability and have a good overview of how applying RME has improved Indonesian students' mathematical literacy. A meta-analysis study is one of the research methods that can integrate various research results with relevant themes.

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Based on the findings, the purpose of this study is to review, estimate, and evaluate the efficacy of using RME in improving students' mathematical literacy skill as well as examine the characteristics of studies that impact varied effect size data. This research is urgent to consider how RME should be applied. This study will provide comprehensive information about the effect of RME in improving literacy. Therefore, It is possible for educators to carry out an ideal learning process to instill and improve students' mathematical literacy skills.

RESEARCH METHODS

This study uses a meta-analysis method, because this research synthesizes various primary studies with a quantitative approach. There are several stages in the meta-analysis study. Greater transparency, detection and reduction of bias, and improved prediction of population parameters, analyzing results across multiple domains, providing significantly strong evidence, and in the synthesis process, strict methodology is used are the advantages of this method (Litte et al., 2008; Litte et al., 2008). According to (Borenstein et al., 2009), several stages of meta-analysis method can be seen in Figure 1.

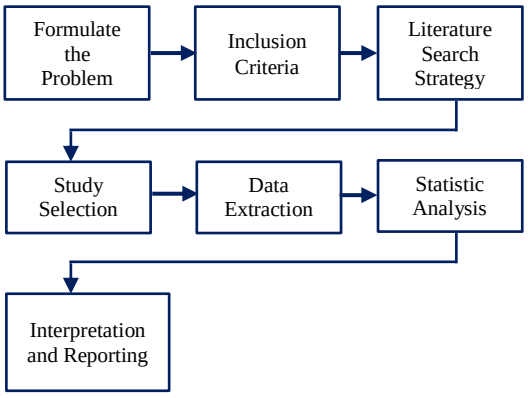

Figure 1. Flowchart of the stages of the meta-analysis method

Therefore, this study will use these stages. The researcher will explain several steps in this section, including inclusion criteria, strategies for searching the literature, data extraction, study selection, and statistical analysis.

Inclusion Criteria

There is still a general and comprehensive preliminary study on the RME approach's impact on students' mathematical literacy. In order to narrow the scope of the meta-analysis, inclusion criteria were based on the PICOS (Population, Interventions, Comparator, Outcomes, and Study Design) approach (Liberati et al., 2009), namely:

1. The primary study's population consists of Indonesian students.
2. The preliminary study's intervention was the use of the RME approach.
3. The previous research compared the intervention to the implementation of conventional learning.
4. The output of the primary study is the students' mathematical literacy ability.
5. The preceding study used quasi-experimental research with a causal-comparative design.
6. The primary statistical data reported were the experimental and control groups' mean, standard deviation, sample size, t-value, and p-value.
7. Primary studies are published in the period 2016-2021, either in journals or proceedings.

The meta-analysis excluded primary studies that did not meet the inclusion criteria.

Literature Search Strategy

The electronic database was used to search for literature on implementing the RME Approach to students' mathematical literacy skills: Google

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Scholar, Semantic Scholar, and URL links from articles. "RME approach" and "Mathematical literacy ability" were used in the literature search. Databases and keywords can assist in locating and locating primary studies that meet the inclusion criteria.

Study Selection

To select the primary study, inclusion criteria were used. (Liberati et al., 2009b) stated that the study selection process consisted of four stages based on the PRISMA protocol (*Preferred Reporting Items for Systematic reviews and Meta-Analysis*): (1) *identification, (2) screening*, (3) *eligibility*, dan (4) *included*.

Data Extraction

After going through the inclusion criteria and study selection stages, the data or information that the researcher extracted, such as the author's name, statistical data (mean, standard deviation, sample size, t-value, and p-value), the year of publication was processed whether it was valid and credible. Valid and credible data will guarantee high-quality meta-analytical study results.

Statistical Analysis

The Hedge's g equation was used to calculate the effect size value in this meta-analysis (Borenstein, 2009). This is because the sample size in the experimental class (RME Class) is relatively small (Harwell, 2020). The classification of effects according to (Cohen et al., 2018) is presented in Table 1.

Table 1. Effect Size Classification according to Cohen.

Effect Size	Interpretation
0,00-0,20	Low
0,21-0,50	Modest
0,51-1,00	Moderate
> 1,00	High

To ensure the validity of the statistical data in each significant study, it is crucial to analyze publication bias and sensitivity because each study result is never free from publication bias (Bernard et al., 2014; Doi & Furuya-Kanamori, 2020). Publication bias analysis was carried out using funnel plots, fill and trim tests, and the Rosenthal fail-safe N test (Harwell, 2020). As for the sensitivity analysis using the "One study deleted" tool in the CMA software (Bernard et al., 2014).

In the meta-analysis study, two kinds of effects are used: the fixed effect model and the random effect model (Borenstein, 2009; Cheung, 2015). The p-value of the Cochran Q statistic is used to determine the effect model chosen in the meta-analysis process as well as the heterogeneity of the effect size data (Borenstein, 2009; Siddiq & Scherer, 2019).

RESULTS AND DISCUSSION

In this study, the number of articles used was nine articles. All articles was choosen based on determined inclusion criteria. The explanation of all articles can be seen in Table 2.

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Table 2. RME article data on mathematical literacy skill

Code	Citation	Statistical Data						T-value
		RME			Conventional Learning			
		Mean	Standard Deviation	Sample Size	Mean	Standard Deviation	Sample Size	
J01	(Umbara & Nuraeni, 2019)	75.1	7.48	31	66.24	12.89	34	
J02	(Fauzana, 2019)	17.91	3.97	32	15.81	3.96	32	
J03	(Kusuma et al., 2016)	62.9	10.52	29	56.21	12.7	24	
J04	(Herutomo & Masrianingsih, 2021)	70.41	5.26	32	66.76	4.77	32	
J05	(Nuraeni & Umbara, 2018)	0.48	0.15	32	0.25	0.23	32	
J06	(Saraseila et al., 2020)	59.47	12.57	32	48.19	15.59	32	
J07	(Istiana et al., 2020)	79.636	14.417	22	63.262	12.368	22	
J08	(Azmi et al., 2018)			30			31	6.70
J09	(Handun et al., 2020)			16			16	7.81

Based on Table 2, nine articles are the RME approach is used in quasi-experimental research of the causal-comparative type with the experimental study. This study's primary goal was to quantify the overall impact of teaching with the RME technique on students' mathematical literacy abilities. The size of an effect is a measure of how much of an influence a treatment has. In this instance, the link between variables is a meta-analysis of how the RME technique affects students' mathematical literacy skills. Of the nine articles, there are five articles with moderate influence and four articles with significant effect. The results of the study are presented in Table 3.

Table 3. Effect size data of article

Citation	Effect Size	Variance	Confidence Interval	
			Lower Limit	Upper Limit
Umbara & Nuraeni, 2019	0.821	0.065	0.320	1.322
Fuzana dkk, 2020	0.523	0.063	0.031	1.016
Kusuma dkk, 2016	0.570	0.077	0.027	1.114
Herutomo & Masrianingsih, 2021	0.718	0.065	0.218	1.218
Nuraeni & Umbar, 2018	1.170	0.072	0.645	1.695
Saraseila et al., 2020	0.786	0.066	0.284	1.290
Istiana dkk, 2020	1.197	0.104	0.565	1.829
Azmi dkk, 2018	1.694	0.087	1.114	2.274
Handun dkk, 2020	2.691	0.232	1.748	3.636

Based on Table 3, the overall range of effect sizes is 0.523 to 2.691, with a 95% confidence level. Based on the study's results, it can be seen that the RME approach positively influences students' mathematical literacy skills.

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This is in accordance with research (Juandi et al., 2022; Shoffa, 2022). Furthermore, the results of the meta-analysis of the primary studies will be presented using the fixed effect model and the random effect model, as shown in Table 4.

Table 4. Effect size transformation each study

Estimation Model	n	Z	p	Effect Size	Standard Error	95% CL		Qb	P-Value	I-Squared
						Lower Limit	Upper Limit			
Fixed	9	10.308	0	0.965	0.093	0.782	1.149	26.885	0.001	70.243
Random	9	6.028	0	1.051	0.174	0.710	1.394			

Table 4 compares the results of the meta-analysis according to the effects model. As illustrated in Table 4, it appears that according to the fixed effects model, the lower limit of the 95% confidence interval is 0.782, and the upper limit is 1.149. The study's overall effect size was 0.965. This effect size is accepted as a moderate effect. In the random effect, the lower limit of the 95% confidence interval is 0.710, and the upper limit is 1.394. The study's overall effect size was 1.051. This effect size is accepted as a strong effect. The next stage is to test for heterogeneity and choose an estimation model. Based on Table 4, the value of Qb is 126,885, and the value of p is 0.001. Thus, the effect size distribution was heterogeneous at $p < 0.05$ (actual effect size varies from study to study). Because the p-value < 0.05, it can be concluded that the overall application of the Realistic Mathematics Education learning approach significantly affects students' literacy abilities compared to conventional learning. The degree of variation in effect size between studies is reflected in the I-squared value of 70,243, which indicates that 70.243% of the variance in the observed effect size reflects the percentage of variability caused by true heterogeneity (not due to sampling error). Thus, this study has high heterogeneity because the I-squared value is 70%. Since the homogeneity test results were rejected, the estimation model used was a random-effect model. Next is to examine publication bias. The following is the funnel plot of the research in Figure 2.

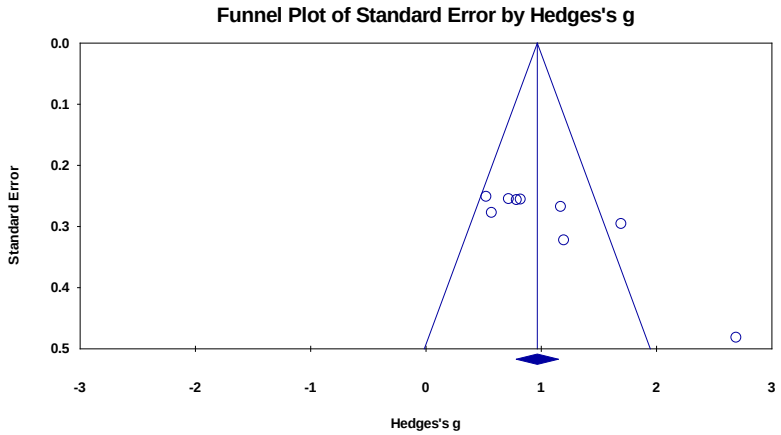

Figure 2. Funnel Plot Check for Publication Bias

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Based on Figure 2, it can be seen that the spread of the effect size is symmetrical around the vertical line. Furthermore, Rosenthal's Fail-Safe N (FSN) statistic was examined. Based on calculations using CMA, the N value was calculated as 269. The result of the calculation of 269 / ((5 x 9) + 10), was 4,891 > 1. The studies included in this analysis are resistant to publication bias. Thus, no studies were lost or needed to be added to the analysis due to publication bias.

The last step is to calculate the p-value to test the research hypothesis. Table 4 compares the results of the analysis according to the estimation model. Based on Table 4, according to the random effect model, the 95% confidence interval ranges from 0.710 to 1.394, which indicates that the mean difference can fall anywhere within this range, and the overall effect size of the study is 1.051. This effect size is acceptable. as a strong effect. As a result of calculating the Z test to determine statistical significance, the z score was found to be 6,028.

This result can be said to be statistically significant at the level of p < 0.001. Thus, applying realistic mathematics Education has a more substantial influence on students' literacy skills than conventional learning models. The next step is to analyze the level of study characteristics by examining the effect of moderator variables on nine effect sizes from nine primary studies, namely education level and student demographics. Hedges-g values, 95% confidence intervals, Z, and p were calculated using the CMA. The following meta-analysis results for study characteristics are presented in Table 5.

Table 5. Results of the meta-analysis of each study characteristics.

Moderator Variable	Group	n	Effect Size	Test of Null (2-Tail)		Heterogeneity		
				Z	P	Between Effect Class (Qb)	Df (Q)	P
Level of Education	Elementary School	4	1,207	3,263	0,001	1,508	2	0,471
	Middle School	4	1,054	4,517	0,000			
	High School	1	0,718	2,816	0,005			
Student Demographics	Districts	5	1,427	5,484	0,000	7,119	1	0.008
	City	4	0,651	5,021	0,000			

Based on Table 5 for the moderating variable of education level, it was found that the research conducted at the elementary school level (1.207) had a more significant effect size than that of middle school (1.054) and high school (0.718). The effect size for elementary school is high, middle school is strong, and high school is moderate. This result accordance with (Tamur et al., 2020). The heterogeneity test results showed that the average effect size between levels of education was different (Q = 1.508 and p > 0.05). Because the p-value > 0.05, the distribution of effect sizes for the three categories of the study characteristics is homogeneous, thus, there is no significant difference in the effect of applying the Realistic Mathematical

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Education Approach to students' mathematical literacy skills based on education level, so it can be concluded that the application of the RME Approach to improve students' literacy skills is not influenced by education level. This result is supported by research (Shoffa, 2022) that examines the effect of RME on students' critical thinking skills and says that the RME approach is more effective at the elementary school level.

For the student demographic moderator variable, it was found that research conducted in districts (1.427) had a more significant effect size than those from cities (0.651). The effect size in the district is categorized as high, while the effect size in the city study is moderate. The heterogeneity test results showed that the average effect size between levels of education was different ($Q = 7.119$ and $p < 0.05$); since the p-value < 0.05, the distribution of effect sizes for both categories on the characteristics of the student demographic study is heterogeneous. Thus, there is a significant difference in the effect of applying the Realistic Mathematical Education Approach to students' mathematical literacy skills based on student demographics, so it can be concluded that the application of the Realistic Mathematical Education Approach to improve students' literacy skills is influenced by the demographics of the students studied. This study (Siddiq & Scherer, 2019; Tamur et al., 2020) showed that the demographic characteristics of students significantly affected the heterogeneity of the effect sizes. It can be interpreted that the implementation of RME would be appropriated the most in students' literacy, especially in districts.

CONCLUSIONS AND RECOMMENDATIONS

The meta-analysis technique used to summarize, estimate, and evaluate nine primary studies shows that the application of RME significantly improves the literacy abilities of Indonesian pupils. This meta-analysis research advises Indonesian math teachers to use RME as one of the best ways to enhance their students' mathematical literacy. The educational factors do not significantly contribute to the heterogeneous impact size of RME implementation in improving students' mathematical literacy. However, descriptively speaking, this meta-analysis research's assessment of the study features suggests to Indonesian mathematics teachers that RME implementation in enhancing students' mathematical literacy should be implemented more in elementary school.

This study recommends that researchers increase the number of primary studies, databases, literature search engines, and prior primary studies indexed by Scopus or Sinta for subsequent meta-analysis studies that explicitly focus on applying RME to improve students' mathematical literacy. The following researchers should also investigate the study's parameters, including the intervention's duration, the sample size, and the study's time period. As a result, the future meta-analysis study will be more qualified according to these suggestions and recommendations.

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