Jurnal Math Educator Nusantara
Wahana publikasi karya tulis ilmiah di bidang pendidikan matematika
p-issn: 2459-9735 e-issn: 2580-9210
http://ojs.unpkediri.ac.id/index.php/matematika

Do differences in measured mathematical abilities moderate the effectiveness of the realistic mathematics education approach? Meta-analysis studies

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Article received : 9 March 2021,
Article revised : 26 March 2021,
Article Accepted : 28 March 2021.
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Abstract: Evidence-based research on the effect of Realistic Mathematical Education (RME) has been conducted. However, whether differences in the measured variables alter the studies' effect sizes have not been explored. To fill this gap, it is necessary to conduct a meta-analysis study that can summarize the evidence for the effect of RME and analyze how the differences in the measured variables are associated with the effect size (ES) of the study. The research sample is an individual study of the effect of RME on various mathematical abilities identified from the ERIC database, the Scopus database, and Google Scholar. Based on the inclusion requirements, 54 independent samples from 38 individual studies were included in the analysis with a total of 6140 students included. The estimation method uses a random-effect model, and the Comprehensive Meta-Analysis (CMA) software is used as a data processing tool. The results of the analysis showed that the ES of the study was 0.97. This shows that overall, the use of RME has a significant effect on students' mathematical abilities. The moderator analysis results explain that the differences in the measured variables moderate the implementation of RME. These findings contribute to the implementation of RME in classrooms and the further development of RME by considering the categories of abilities being measured.

Keywords: Realistic Mathematics Education, Measured variables, Meta-analysis, Effect sizes

INTRODUCTION

After two decades since the emergence of the realistic mathematic education (RME) approach (Van den Heuvel-Panhuizen & Drijvers, 2020), many researchers and educators have applied it to learning mathematics in many countries, including Indonesia (Prahmana, Sagita, Hidayat, & Utami, 2020). RME has its characteristics, including context as a starting point for learning to link students' knowledge with the concepts to be studied. RME emerged as an innovative approach rather than a conventional approach where the mathematics teaching process is presented mechanically.

The use of contexts such as stories and games, pyramids, coins as a starting point for learning is alleged to foster students' mathematical abilities and make mathematics learning more enjoyable (Risdiyanti et al., 2020; Özdemir, 2017). In order to test this theoretical assumption, several studies have been carried out which provide inconsistent results. Some

CITATION FORMATS:
Tamur, M., Ndiung, S., Nurjaman, A., & Pereira, J. (2021). Do differences in measured mathematical abilities moderate the effectiveness of the realistic mathematics education approach? Meta-analysis studies. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah Di Bidang Pendidikan Matematika*, 7(1), 12-25. https://doi.org/10.29407/jmen.v7i1.15736

research results, for example, report the superiority of RME over conventional approaches to students' mathematical abilities (e.g., Hirza, Kusumah, Darhim & Zulkardi et al. 2014; Saleh, Prahmana, Isa & Murni, 2018; Son, Darhim, Fatimah, 2020). RME can significantly improve students' mathematical abilities. However, several other studies report that RME is no better than conventional approaches to students' mathematical abilities, as reported by Ndiung, Dantes, Ardana, & Marhaeni (2019) and Yuniati, Armiati, & Musdi (2020).

The inconsistency of research results regarding the effects of RME, as shown previously, has the potential to provide inaccurate conclusions (Juandi, Kusumah, Tamur, Perbowo, & Wijaya, 2021; Suparman, Juandi, et al., 2021b). This is confirmed by Franzen (2020) that several studies of the same individual sometimes have different and even contradictory results, and as a result, concluding research questions can be subjective. On the other hand, educators need objective information about the effects of RME and the features of the studies that need to be considered.

In an effort to bridge this gap, a meta-analysis study summarizing the evidence on the effects of RME is needed to explain the overall effectiveness of RME and to understand the relationship between mathematical ability and the role of moderator in the application of RME. Meta-analysis studies can provide in-depth and accurate conclusions and valuable information for policymaking (Higgins & Katsipataki, 2015; Siddaway, Wood, & Hedges, 2019). In addition, statistical techniques in the meta-analysis were developed to summarize the overall results of individual studies and estimate the overall effect size of the studies (Juandi & Tamur, 2020; Tamur, Juandi, & Kusumah, 2020).

In line with that, previously, Tamur, Juandi, & Adem (2020) have conducted a meta-analysis study to determine the overall effect of RME and determine the role of moderators such as study year, sample size, treatment duration, publication source, and education level. The extent to which differences in the measured variables moderate the effect sizes of the studies has not been questioned. The study is also weak in terms of data sources where the independent sample analyzed only comes from individual studies conducted in Indonesia. Meanwhile, analysis of studies from within the country and abroad is needed to provide a more comprehensive meta-analysis (Çiftçi & Yıldız, 2019). In addition, most of these studies only analyzed unpublished research results such as master's thesis, thesis, and doctoral studies. Meanwhile, analyzing only the findings of such unpublished works in a meta-analysis can cause publication bias problems (Borenstein, Hedges, Higgins, Rothstein, 2009).

This meta-analysis extends previous studies by limiting the independent samples analyzed, namely domestic and foreign studies. The first focus is on determining the overall effect size of the study and is followed by examining how differences in the measured variables moderate the effect sizes of the studies. These findings will contribute to the literature that provides essential information for further RME implementation. In order to achieve the research objectives, these two questions were tested: first, whether the overall effect size of the RME had a significant effect (the ES effect size of the large study category) on students' mathematical abilities. Second, the extent to which the differences in the measured variables moderate the effect sizes of the RME studies.

METHOD

The meta-analysis method is implemented in this study. In general, Borenstein et al. (2009) describe the stages of the meta-analysis, namely first, inclusion criteria are defined for the individual studies analyzed. Second, the empirical data collection procedures and the coding of study variables were defined. Third, statistical analysis is applied. This research has followed that stage. This stage has been implemented by other researchers in the field of education, for example (Turgut & Turgut, 2018; Juandi et al., 2021; Paloloang et al., 2020; Suparman et al., 2021; Susanti et al., 2020; Tamur & Juandi, 2020; Yunita et al., 2020; Suparman, Tamur, et al., 2021; Tamur, Kusumah, et al., 2021; Sari et al., 2021). This research has also followed these stages which are detailed as follows:

Inclusion Criteria

All individual study articles were assessed for inclusion in the meta-analysis using the following inclusion criteria:

(a) Written in English published in the last two decades.
(b) Peer-reviewed publications.
(c) Each study should report experimentally on the effects of RME and use a control class as a comparison
(d) Individual studies must explicitly report the sample sizes, means, and standard deviations of the two groups.

Data collection

The research sample is an individual study of the effect of RME on students' mathematical abilities. This is obtained from electronic databases including ERIC, sage publishing, springer publishing, semantic scholar, and google scholar with relevant keywords (see Figure 1) to identify articles. Figure 1 presents the selection and reporting of data using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes). This protocol includes four stages: identification, screening, eligibility, and inclusion. We used the PRISMA protocol in reporting data selection because it was more waiting than other types (Nawijn et al., 2019). The PRISMA protocol is a data selection and reporting process that supports transparency and quality in a systematic review and meta-analysis (Pigott & Polanin, 2020).

The identification results found 241 studies that were contents the effect of RME. The screening stage provided 189 individual studies, but 103 were excluded because they did not meet the inclusion criteria. Subsequently, 48 studies were excluded from the analysis because they did not contain sufficient statistical data. This process provided the final results of 38 studies for analysis. However, because there was more than one experimental or control group in several studies, this study analyzed 54 independent samples. The individual studies included in the analysis are given in appendix 1.

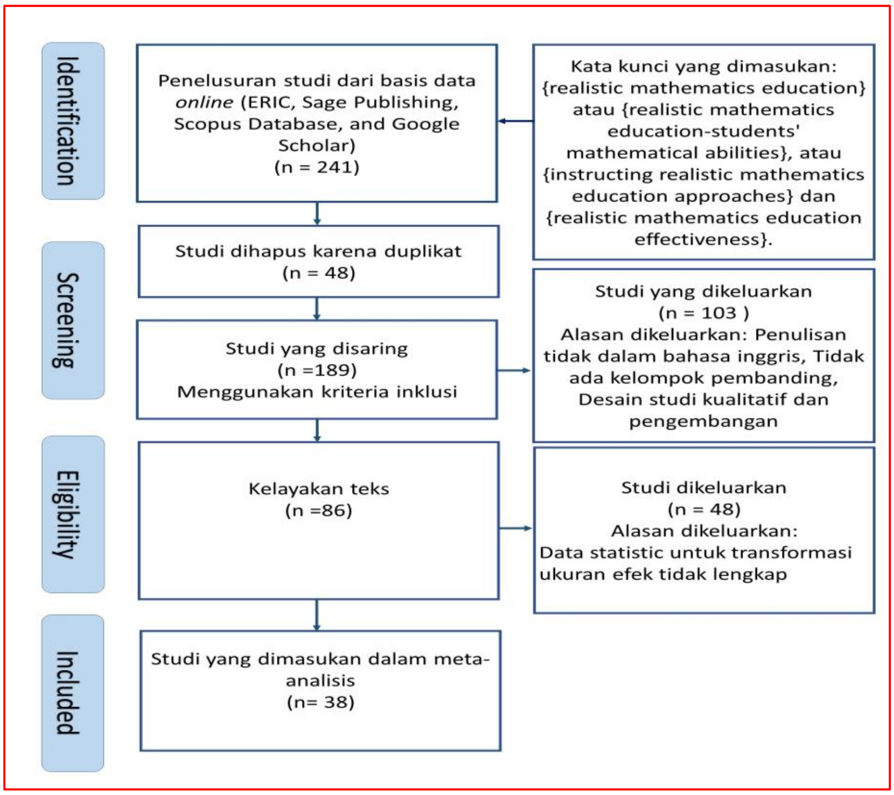


Figure 1. Selection of studies on the effects of RME using the PRISMA protocol

Furthermore, 38 individual studies were coded using coding sheets as research instruments. The coded information includes the name of the study, year of study, statistical data for effect size transformations, and categories of variables measured. The coding reliability was carried out by involving two researchers outside the research project. After they entered the data, the Cappa Cohen coefficient was then applied (κ (7)). McHugh (2012) explains that (κ (7)) is a strong statistic to test the level of agreement between coders given by; menjelaskan bahwa (κ (7)) adalah statistik kuat untuk menguji tingkat kesepakatan antar pengkode yang diberikan oleh; $\kappa(7) = \frac{pr_{(a)}-pr_{(e)}}{1-pr_{(e)}}$

Pr (a) represents a factual agreement, and Pr (e) represents a coincidence agreement. A value of 0.85 or greater is considered high. The value obtained in this study is 0.86 which means, there is a high similarity between coders. Thus, the data included in this meta-analysis are reliable.

Data analysis

Like most meta-analyzes, this study uses the effect size (ES) as the unit of analysis. ES reflects the magnitude of the effect of RME on students' mathematical abilities whose calculations are assisted by Comprehensive Meta-Analysis (CMA) software. The ES equation we use is Hedges'g because it is considered correct for the bias of the effect of a small sample (Harwell, 2020). At the same time, the ES category uses the classification of Cohen et al. (2018) that is, less than or equal to 0.2 (weak effect), between 0.21 to 0.50 (simple effect), between 0.51 to 1.00 (moderate effect), more than 1.00 (strong effect). This study assumes that all studies estimate different actual effects, and therefore the estimation method uses a random-effect model (Pigott, 2012). The statistical hypothesis (h_0), which reflects the homogeneity of the research results or categorical variables, is rejected if the p-value is <0.05. The influence of publication bias was investigated using a funnel plot assisted by the Trim and Fill test.

RESULTS AND DISCUSSION

Research Results to Answer the First Question

The first objective of this study is to reveal the magnitude of the overall effect of using RME. For this purpose the CMA calculates the effect size of each study. Figure 2 presents a forest plot of effect sizes and standard errors for each study.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Huntley et al., 2000a	0,457	0,083	0,007	0,294	0,621	5,478	0,000
Huntley et al., 2000b	0,441	0,083	0,007	0,277	0,604	5,280	0,000
Huntley et al., 2000c	0,362	0,083	0,007	0,200	0,525	4,362	0,000
Fauzan 2002, a	0,401	0,236	0,056	-0,061	0,864	1,700	0,089
Fauzan 2002, b	1,360	0,266	0,071	0,839	1,880	5,120	0,000
Fauzan 2002, c	0,320	0,243	0,059	-0,155	0,796	1,321	0,187
Palinussa, 2013a	0,571	0,298	0,089	-0,013	1,156	1,915	0,055
Palinussa, 2013b	0,702	0,268	0,072	0,176	1,228	2,617	0,009
Zaranis et al., 2013a	0,123	0,261	0,068	-0,388	0,635	0,473	0,636
Zaranis et al., 2013b	0,637	0,270	0,073	0,107	1,167	2,356	0,018
Zaranis et al., 2013c	0,434	0,272	0,074	-0,100	0,968	1,592	0,111
Susanti et al., 2014a	0,546	0,150	0,022	0,252	0,839	3,639	0,000
Susanti et al., 2014b	0,465	0,278	0,078	-0,080	1,011	1,672	0,095
Susanti et al., 2014c	0,424	0,177	0,031	0,078	0,770	2,401	0,016
Hirza et al., 2014	0,854	0,163	0,027	0,535	1,174	5,237	0,000
Zubainur et al., 2014	0,841	0,295	0,087	0,263	1,420	2,851	0,004
Wardono et al., 2016a	1,166	0,287	0,082	0,604	1,728	4,069	0,000
Wardono et al., 2016b	1,783	0,319	0,102	1,158	2,408	5,593	0,000
Mahendra, 2017	1,475	0,284	0,081	0,918	2,032	5,189	0,000
Habsah, 2017a	2,071	0,323	0,104	1,439	2,704	6,418	0,000
Habsah, 2017b	1,902	0,314	0,098	1,287	2,517	6,062	0,000
Karaca et al., 2017	1,214	0,324	0,105	0,578	1,850	3,740	0,000
Supandi et al., 2017	0,681	0,242	0,059	0,206	1,156	2,808	0,005
Zakaria et al., 2017	0,969	0,271	0,073	0,438	1,500	3,580	0,000
Sumirattana et al., 2017a	1,018	0,208	0,043	0,609	1,426	4,884	0,000
Sumirattana et al., 2017b	2,024	0,241	0,058	1,551	2,497	8,393	0,000
Yuanita, 2018a	-0,364	0,098	0,010	-0,556	-0,173	-3,727	0,000
Yuanita, 2018b	1,004	0,103	0,011	0,802	1,206	9,763	0,000
Laurens et al, 2018	2,724	0,393	0,154	1,955	3,494	6,937	0,000
Altiparmak et al., 2018	1,172	0,239	0,057	0,704	1,641	4,903	0,000
Septriyana et al., 2018	1,797	0,375	0,140	1,063	2,531	4,796	0,000
Sofiyah et al., 2018	2,612	0,335	0,112	1,956	3,269	7,795	0,000
Ramdhani et al., 2018	1,374	0,287	0,082	0,811	1,936	4,786	0,000
Laurens, 2018	0,713	0,305	0,093	0,115	1,311	2,337	0,019
Warsito et al., 2018	1,409	0,263	0,069	0,893	1,925	5,352	0,000
Suryani., 2018	0,492	0,313	0,098	-0,122	1,106	1,572	0,116
Kusumaningsih., 2018	2,815	0,348	0,121	2,133	3,497	8,088	0,000
Febriyanti., 2019	1,800	0,340	0,116	1,133	2,467	5,291	0,000
Hasbi et al., 2019	1,922	0,305	0,093	1,325	2,520	6,306	0,000
Ndiung, 2019a	0,823	0,206	0,043	0,419	1,227	3,991	0,000
Ndiung, 2019b	0,035	0,200	0,040	-0,357	0,427	0,173	0,863
Pertiwi, 2019	1,090	0,258	0,067	0,584	1,595	4,223	0,000
Amrina, 2019	0,946	0,330	0,109	0,299	1,593	2,864	0,004
Junaedi, 2019	0,404	0,229	0,052	-0,044	0,852	1,767	0,077
Umbara, 2019	0,831	0,259	0,067	0,324	1,338	3,211	0,001
Ndiung et al., 2019a	0,035	0,199	0,040	-0,355	0,426	0,178	0,859
Ndiung et al., 2019b	0,869	0,208	0,043	0,461	1,277	4,173	0,000
Marpaung et al., 2020	0,620	0,252	0,064	0,126	1,115	2,457	0,014
Dwi et al., 2020	0,664	0,270	0,073	0,135	1,193	2,462	0,014
Son et al., 2020	1,418	0,230	0,053	0,968	1,868	6,176	0,000
Yerizon, 2020	1,926	0,302	0,091	1,334	2,519	6,369	0,000
Kurino, 2020	1,323	0,349	0,122	0,638	2,007	3,789	0,000
Yuniati, 2020a	0,143	0,256	0,066	-0,359	0,646	0,559	0,576
Yuniati, 2020b	1,435	0,290	0,084	0,868	2,003	4,957	0,000
	0,985	0,086	0,007	0,817	1,154	11,450	0,000

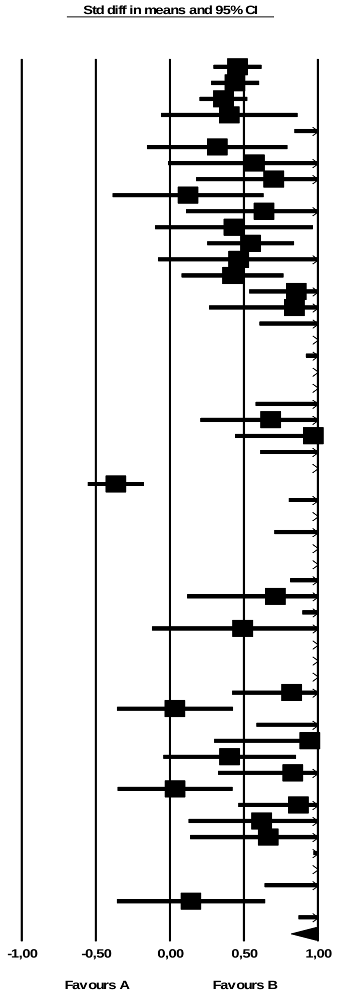


Figure 2. The research forest plot

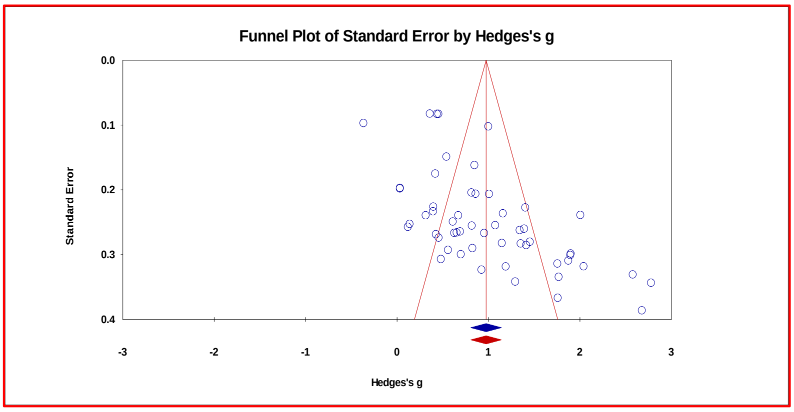
In Figure 2, we use the first author and year of publication to represent each study. To represent studies with more than one independent sample, we use the notations a, b and c. Based on Figure 2, the effect size of using RME looks inconsistent. This reflects a moderating effect on the effect size of the study. Table 1 shows the comparison of the results based on the estimation method.

Table 1. Research results based on the estimation method

Model	N	Hedges's g	*Standard error*	*95% Confidence Interval*		Q	P	Decision
				Lower	*Upper*			
Fixed-effect	54	0.67	0.02	0.62	0.72	487.19	0.00	Decision
Fixed-effect	54	0.97	0.08	0.80	1.14			

Table 1 shows that the p-value <0.05 means rejecting the hypothesis that all study effect sizes are the same. In other words, statistically, the effect size of each study was found to be heterogeneous. This means the estimation model fits into the random-effect model. This implies that further analysis is needed to investigate the causes for these variations (Arik & Yilmaz, 2020; Zhang et al., 2019).

Next, the study funnel plots in Figure 2 were included to check for publication bias. If the ES of 54 independent samples is spread symmetrically between the vertical lines, there is no effect of publication bias (Borenstein, Hedges, Higgins, et al., 2009). However, because the ES distribution was not completely symmetrical, we used the Trim and Fill test to see the impact of publication bias. The rule is that if there is no difference between the observed ES and the virtual ES created according to the random-effect model, then there is no bias effect (Tamur, Jehadus, Habibi et al., 2021; Suparman, Juandi, & Tamur, 2021b). Figure 3 presents the research funnel plot.



Gambar 3. Plot corong penelitian

Based on the illustration of the spread of ES in Figure 3, the ES scattered studies are not all symmetrical between the vertical lines. Consequently, the effects that occur as a result of publication bias need to be examined. Concerning that, the Trim and Fill test was carried out to evaluate the extent to which the effect was associated with publication bias in the effect sizes obtained from the meta-analysis carried out according to the random-effects model. The results are presented in Table 2.

Table 2. Trim and Fill test results

	Studies Trimmed	*ES*	*Confidence Interval*		*Q Value*
			Lower Limit	*Upper Limit*	
Observed values		0. 97	0.08	0.97	487.19
Adjusted values	0	0. 97	0.80	1.14	487.19

Based on Table 2, it can be seen that there is no difference between observed ES and virtual ES created according to the random-effect model from both sides. This reflects that there is no effect of publication bias in the study. Thus, there is no need for independent samples to be added or trimmed due to publication bias.

Research Results to Answer the Second Question

The analysis results show a heterogeneous distribution of ES so that the ability variable measured in the study of the effect of RME is considered to affect the effectiveness of the RME should be investigated. Figure 4 provides a summary of the analysis results exported from the CMA.

Groups		Effect size and 95% confidence interval					Test of null (2-Tail)		Heterogeneity		
Group	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value
Fixed effect analysis											
Berpikir	4	0,357	0,120	0,014	0,122	0,592	2,974	0,003	4,822	3	0,185
HOTS	3	0,490	0,106	0,011	0,283	0,698	4,639	0,000	0,286	2	0,867
Ketrampilan	2	0,927	0,146	0,021	0,641	1,213	6,359	0,000	0,978	1	0,323
Komunikasi	2	1,915	0,218	0,047	1,488	2,342	8,792	0,000	0,003	1	0,956
Koneksi	2	1,868	0,227	0,052	1,423	2,313	8,227	0,000	0,072	1	0,789
Literasi	5	1,327	0,114	0,013	1,104	1,550	11,655	0,000	16,587	4	0,002
Numerik	2	0,435	0,144	0,021	0,152	0,718	3,016	0,003	8,350	1	0,004
Pemahaman	6	0,568	0,068	0,005	0,435	0,701	8,359	0,000	21,585	5	0,001
Pemecahan	7	0,821	0,058	0,003	0,707	0,934	14,172	0,000	64,343	6	0,000
Penalaran	3	1,440	0,165	0,027	1,117	1,763	8,729	0,000	5,725	2	0,057
Prestasi	12	0,808	0,078	0,006	0,655	0,962	10,302	0,000	52,440	11	0,000
Representasi	6	0,249	0,058	0,003	0,136	0,362	4,306	0,000	118,784	5	0,000
Total within									293,976	42	0,000
Total between									196,237	11	0,000

Figure 4. Summary of the results of the moderator analysis

Figure 4 shows the 12 ability categories measured about the effects of RME in the study. Of the 54 independent samples analyzed, 12 of them tested students' mathematical learning achievement. After seven independent samples testing mathematical problem-solving abilities, each of the six independent samples tested mathematical comprehension and representation abilities. Then, five independent samples tested mathematical literacy skills, and four independent samples tested mathematical thinking skills, three independent samples each tested reasoning skills and HOTS (high order thinking skills). Finally, each of the two independent samples tested intuition, communication, connection, and numerical abilities.

Discussion

This meta-analysis research has been conducted taking into account transparent and high-quality reporting standards such as PRISMA. Although the list analyzed more studies, only 38 were eligible. It seems that individual studies of the effects of RME have been dominated by design, qualitative, and development research. This is because 43 independent samples, or 79% of the studies analyzed, came from Indonesia. This is in line with Prahmana et al. (2020) report that design research dominates RME research in two decades of RME in Indonesia.

The analysis results based on the random-effects model (see Table 1) found that the overall effect size of the study was 0.97. Based on the classification of Cohen et al. (2018) This ES shows that the application of RME has a moderately positive effect on students' mathematical abilities. This is very possible because RME concentrates students to work together, discuss, think, and solve real problems in everyday life. This result is almost the same as the results of previous research conducted by Tamur, Juandi, & Adem (2020) who reported ES 1.10 when they analyzed 72 individual studies on the effect of RME on students'

ISSN 2459-9735 (print), ISSN 2580-9210 (online)

mathematical abilities in Indonesia. In addition, the results of Chen, Shih, & Law (2020) also support this study, although their meta-analysis of the effects of game-based learning may be similar to the characteristics of RME. The similarity of these results shows a trend about the advantages of RME, which should be considered by educators, researchers and other related parties.

Hasil analisis moderator (lihat gambar 4) memperlihatkn bahwa nilai-P pada total between adalah 0,000<0,05. Ini berarti ukuran efek dari 12 variabel kategori berbeda secara signifikan. Dengan perkataan lain variabel kemampuan yang diukur memoderasi pengaruh RME. Hasil ini didukung oleh laporan meta-analisis sebelumnya yang menemukan adanya pengaruh variabel moderator terhadap efektivitas RME. Misalnya, Tamur, Juandi, & Adem (2020) found that the effect of RME on mathematical ability was moderated by sample size and treatment duration. They reported that the implementation of RME would achieve high effectiveness in settings with a sample size of fewer than 31 people and a treatment duration of fewer than three sessions. The results of other meta-analyses on learning similar to RME, such as CTL (contextual teaching and learning), also support this finding. For example, Tamur, Jehadus, Nendi, et al. (2020) found that the effectiveness of CTL was moderated by sample size. They recommended that a sample size of less than 31 would have a more significant effect than CTL application. Furthermore, to compare the ES for each category, Figure 5 presents a clear history of the ES mean of each categorical variable.

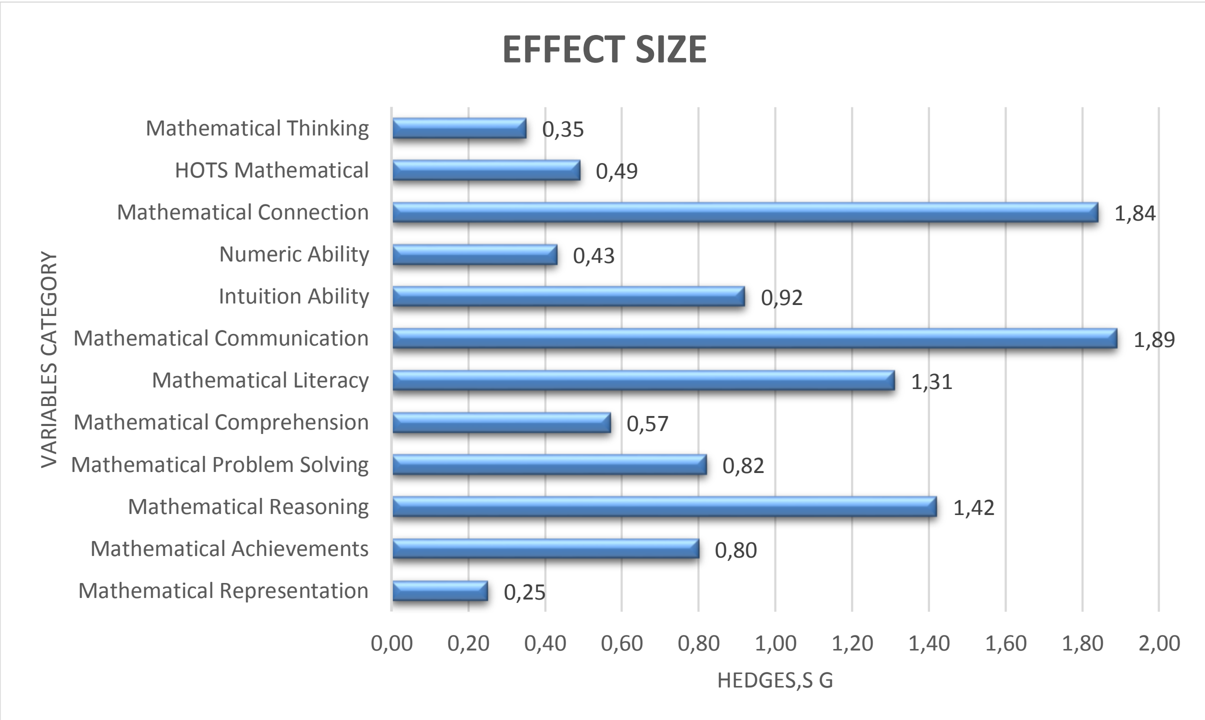


Figure 5. Average ES of each categorical variable

Figure 5 shows the ES differences of the 12 categorical variables. It can be compared that RME is weak in testing mathematical representation skills (ES = 0.15), numerical abilities (ES = 0.43), mathematical HOTS (0.49), and mathematical thinking skills (ES = 0.35). On the other hand, RME can be recommended to test abilities such as mathematical connections (ES = 1.84), mathematical communication (ES = 1.89), mathematical literacy (ES = 1.31), and mathematical reasoning (ES = 1.42). However, this study has not yet further analyzed why these differences occur and are related to one another. Further study is required to research.

CONCLUSION

Research has been conducted to summarize the evidence on the effects of RME in the last two decades. The analysis results conclude that the implementation of RME is favourable for students' mathematical abilities compared to conventional learning. However, it is necessary to consider the measured categorical variables. RME has a strong impact in measuring mathematical connection skills, mathematical communication, mathematical literacy, and mathematical reasoning. On the other hand, RME is weak in measuring mathematical representation skills, numerical abilities, mathematical HOTS, and mathematical thinking skills. However, this research is only based on specific criteria which can be reached through an online database. Although this study involved research results from abroad, the independent sample analyzed was very limited. Therefore, it requires collaborative researchers across countries so that they can work together to achieve maximum results

ACKNOWLEDGMENTS

I would appreciate Prof. Michael Borenstein and the CMA team for all their technical assistance and contributions to this research project.

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Appendix 1. Name and title of study included in the meta-analysis

Nama Studi	Judul
Huntley et al., 2000	Effects of Standards-Based Mathematics Education: A Study of the Core-Plus Mathematics Project Algebra and Functions Strand
Fauzan, 2002	Applying Realistic Mathematics Education (RME) in Teaching Geometry In Indonesian Primary Schools
Palinussa, 2013	Students' Critical Mathematical Thinking Skills and Character: Experiments for Junior High School Students through Realistic Mathematics Education Culture-Based
Zaranis et al., 2013	The Use of ICT and the Realistic Mathematics Education for Understanding Simple and Advanced Stereometry Shapes Among University Students
Susanti et al., 2014	Computer-Assisted Realistic Mathematics Education for Enhancing Students' Higher-Order Thinking Skills
Hirza et al., 2014	Improving Intuition Skills with Realistic Mathematics Education
Zubainur et al., 2014	The effect of using Indonesian realistic mathematics education (PMRI) approach on the mathematics achievement amongst primary school students
Wardono et al., 2016	Mathematics Literacy on Problem Based Learning with Indonesian Realistic Mathematics Education Approach Assisted E-Learning Edmodo
Mahendra et al., 2017	Problem Posing with Realistic Mathematics Education Approach in Geometry Learning
Habsah, 2017	Developing Teaching Material Based on Realistic Mathematics and Oriented to the Mathematical Reasoning and Mathematical Communication
Karaca, 2017	The Effects of Realistic Mathematics Education on Students' Math Self Reports in Fifth Grades Mathematics Course
Supandi, 2017	Analysis Of Mathematical Representation By React Strategy On The Realistic Mathematics Education
Zakaria, 2017	The Effect of Realistic Mathematics Education Approach on Students' Achievement And Attitudes Towards Mathematics
Sumirattana et al., 2017	Using realistic mathematics education and the DAPIC problem-solving process to enhance secondary school students' mathematical literacy
Yuanita et al., 2018	The effectiveness of Realistic Mathematics Education approach: The role of mathematical representation as moderator between mathematical belief and problem solving
Laurens et al., 2018	How Does Realistic Mathematics Education (RME) Improve Students' Mathematics Cognitive Achievement
Altiparmak et al., 2018	An Experimental Study on the Effectiveness of Computer Aided Realistic Mathematics Education
Septriyana et al., 2018	The Influence of Realistic Mathematics Education (RME) Approach on Students' Mathematical Problem Solving Ability
Sofiyah et al., 2018	The Influence of Realistic Mathematics Education (RME) Approach Based on Mandailing Culture on Student Self-Regulated Learning in Class V of Islamic Elementary School Sihadabuan Padang sidimpuan
Ramdhani et al., 2018	Comparison of Mathematical Reasoning of SMP Students Between Learning Using A Realistic Approach with Open Ended Approach
Laurens, 2018	The Effectiveness of Local Wisdom Based-Realistic Mathematics Learning to Improve Learners' Characters at State Elementary Schools in Ambon City
Warsito et al., 2018	Improving students' mathematical representational ability through RME-based progressive mathematization
Suryani et al., 2018	Improving the Mathematical Representation and Self Confidence through Realistic Mathematics Education Approach for Junior High School
Kusumaningsih et al., 2018	Improvement Algebraic Thinking Ability Using Multiple Representation Strategy on Realistic Mathematics Education
Febriyanti et al., 2019	The Effect of The Realistic Mathematics Education (RME) Approach and The Initial Ability of Students on The Ability of Student Mathematical Connection

Nama Studi	Judul
Hasbi et al., 2019	Mathematical Connection Middle-School Students^{8th} in Realistic Mathematics Education
Ndiung, 2019	Treffinger Creative Learning Model with RME Principles on Creative Thinking Skill by Considering Numerical Ability
Pertiwi, 2019	Enhancing mathematical reasoning ability and self confidence students' through realistic mathematics education approach with geogebra
Amrina et al, 2019	Using Realistic Mathematics Education Approach to Learn Linear Program
Junaedi et al., 2019	Improving Student's Reflective Thinking Skills Through Realistic Mathematics Education Approach
Umbara et al., 2019	Implementation of Realistic Mathematics Education Based on Adobe Flash Professional CS6 to Improve Mathematical Literacy
Ndiung et al., 2019	The Treffinger Learning Model with RME Principles on Mathematics Learning Outcome by Considering Numerical Ability
Marpaung et al., 2020	The Effect of Mathematics Realistic Education Aided by Mathematics Software towards the Process of Solving Mathematical Communication Problems of Junior High School Students
Dwi et al., 2020	The Effect of Realistic Mathematics Education (RME) on The Understand Mathematical Concepts Skills of Elementary Students Using Hypothetical Learning Trajectory (HLT)
Son et al., 2020	Students' Mathematical Problem-Solving Ability Based on Teaching Models Intervention and Cognitive Style
Yerizon et al., 2020	Improving Student's Mathematical Communication Skills Through Mathematics Worksheet Based on Realistic Mathematics Education
Kurino et al., 2020	The Effect of Realistic Mathematic Education towards Student' Learning Motivation in Elementary School
Yuniati et al., 2020	The influence of realistic mathematics education (RME) approach with the TANDUR on understanding the concepts and solving mathematical problems on grade 8 in smp negeri 1 pantai cermin

Note: We used first author and year of publication to represent each study