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Meta-Analysis Study: Effect of Realistic Mathematics Education Implementation on Student's Mathematics Achievement

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Abstract

Since there hasn't been a thorough analysis of how the application of Realistic Mathematics Education (RME) affects students' mathematical proficiency, many teachers are ignorant of the benefits this approach offers to pupils. The purpose of this meta-analysis study was to examine the overall impact of implementing the RME on students' mathematical proficiency. Scopus, ERIC, Sage Publications, Springer Publications, JSTOR, and Google Scholar were the direct sources of the empirical data. Seventeen articles published between 2014 and 2023 are the results of the search. Ten items were eligible for analysis based on the inclusion criteria. A random estimating approach was applied, and the analysis was conducted using Jamovi software. The study's total effect size was determined to be significant based on the results (Hedges' g = 1.21). According to these results, pupils exposed to RME outperformed those in traditional learning environments by more than one standard deviation. After analyzing the moderator variables, it was shown that sample size, educational attainment, and geographic location all affected the impact sizes. RME was most successful at the primary education level, and trials with smaller sample sizes indicated bigger impact sizes. Effect sizes were marginally larger in urban studies than in rural ones. With ramifications for future study and educational practice, the results indicate that RME is a potent instructional strategy that can greatly improve mathematical achievement. Ghanaian mathematics teachers are advised by this meta-analysis study to utilize RME more often, particularly in elementary schools, since it has been shown to improve pupils' mathematical achievement.

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Introduction

It may be said that those who are strong at mathematics will succeed in life and have opportunities because mathematics is a component of many aspects of people's daily and academic lives as well as their careers (Akosah et al., 2025; Johnson & Fitzmaurice, 2025). However, it is widely acknowledged that a large number of people exhibit the mindset that mathematics is not their forte (Turgut, & Turgut, 2018). Students' attitudes toward mathematics may be influenced by their methods of learning the subject. According to Akosah et al. (2024), junior high school students in Ghana continue to perform below expectations in mathematics, necessitating the development of teachers and the implementation of efficient teaching methods. Relevant teaching strategies can improve students' mathematics performance (Marzuki et al., 2025). Similarly, Çakıroğlu, et al., (2024) emphasized how crucial it is for students to relate their mathematical education to real-world situations. According to Laurens et al. (2018) and Özdemir (2017), students' mathematical achievement can be improved and mathematics can be made more interesting by using context as a beginning point for learning. One characteristic of the Realistic Mathematics Education (RME) approach is learning that starts with this actual scenario.

Students' performance in mathematics can be enhanced by a variety of educational strategies. In the RME, students begin with scenarios and issues from the "real" world then, with the teacher's help and supervision, reimagine mathematical notions and concepts (Shanty, 2023). RME is a novel approach to teaching mathematics (Van den Heuvel-Panhuizen & Drijvers, 2014). The Freudenthal Institute expanded on the RME theory of mathematics education, which was developed by Dutch mathematician Hans Freudenthal (Treffers, 1987). In contrast to traditional mathematics instruction, RME originated as a novel technique (De Corte, 2000). According to Van den Heuvel-Panhuizen (2003), traditional mathematics teaching involves presenting mathematics as a prefabricated standard system and instructing students using mechanical methods. According to Freudenthal (1973), mathematics is a human endeavor. According to Freudenthal (1991), mathematics is not a subject or body of information that should be taught. Real-world problems are the foundation of mathematics, and these problems are then mathematized to produce formal mathematics (Gravemeijer & Terwel, 2000). The word "real" describes actual circumstances as seen via an experimental lens. Problems must be presented in a way that allows students to experience them through action, not just real-life scenarios (Gravemeijer & Doorman, 1999). Students' experiences and reality must be tightly tied to mathematics teaching (Van den Heuvel-Panhuizen, 2003). Opportunities for students to rediscover mathematics should be provided, according to RME. In order to make teaching mathematics enjoyable and advantageous for the students, a link between mathematics and the actual world must be established (Van den Heuvel-Panhuizen, 2003). When students understand the practical applications of mathematics, their learning will improve. What is unique about this technique is that it places rich and "realistic" scenarios at the center of learning exercises. Students' basic knowledge is explored in this setting, which progressively becomes more formal (Van den Heuvel-Panhuizen & Drijvers, 2014). International curricula and the study of colored mathematics were influenced by RME today (Prahmana, Sagita, et al., 2020). Teachers can help students become more proficient in mathematics by using RME (Hasibuan et al., 2019). This is because RME gives students the skills they need to solve real-world problems, engage in critical thinking, and have discussions. This suggestion led to a flurry of RME research.

The RME approach is known to affect students' mathematical performance. Prior research on this theoretical premise, however, yielded conflicting findings. Research shows that the RME technique works (Akosah et al., 2025; Ali et al., 2021; Saleh et al., 2018; Son et al., 2020). Some research findings, however, contradict these conclusions (Yuniati et al., 2020). Several studies have looked into whether or not RME implementation in nations like Indonesia, Malaysia, Turkey, United State of America, Germany, etc., significantly improves students' mathematical achievement. The findings of these investigations differ. RME implementation has been found to have good effects by several researches (Ali et al., 2021; Hasibuan, et al., 2019; Shanty, 2023). Naturally, the results' heterogeneity creates new issues, primarily due to the mention of those who think RME influences students' achievement in mathematics. Conclusions about research concerns can be subjective because many investigations within a single study often yield inconsistent results (Franzen, 2020; Juandi & Tamur, 2021). Teachers are looking for specific data that they may use to apply RME. Mathematics teachers need this information to choose suitable alternative learning models to enhance mathematics teachings in the classroom, and educational officials need it to create the framework for implementing education in Ghana. To bridge this gap and provide policymakers with relevant data, quantitative studies must be incorporated (Higgins & Katsipataki, 2015). Therefore, this issue recommends conducting a more comprehensive study to examine the variability of all the findings and have a clear picture of how RME deployment has raised students' mathematical achievement. In order to combine and assess the results of different investigations and to examine the reasons behind result variance for their potential future usage, a meta-analysis study is necessary.

Meta-analysis is a quantitative research method that takes effect size into account as a measurement factor and integrates data on the strength of correlation, influence, and relationships between variables by combining the results of prior studies (Fadhli et al., 2020; Siddaway et al., 2019). The application of the RME effect has been the subject of meta-analysis research. For instance, research findings from a study by Juandi et al. (2021) looked at the application of RME over the past 20 years. This indicates that students' performance in mathematics is significantly improved by the use of RME. There is currently a dearth of meta-analysis research on students' mathematical achievement. Therefore, this study employs sample size, educational stage, and student demographic location as moderator variables to examine how RME might be implemented to enhance students' mathematical achievement. This study aims to review, estimate, and assess the effectiveness of RME implementation in raising students' mathematical achievement based on the results. It also looks at the features of studies that affect different effect size data. The implementation of RME is a pressing topic for this research. This study will offer thorough details regarding how using RME can raise students' mathematical achievement. Therefore, teachers can implement the optimum learning approach to inculcate and increase students' achievement in mathematics.

Research Questions

1. What is the overall effect of RME implementation on students' mathematics achievement?
2. Does the effect size of RME implementation on students' mathematics achievement differ according to the sample size?
3. Does the effect size of RME implementation on students' mathematics achievement differ according to

the stage of education?

4. Does the effect size of RME implementation on students' mathematics achievement differ according to the geographical distribution of studies?

Methods

This study used the meta-analysis method. By examining the quantitative findings from several research on a certain subject, a meta-analysis offers a broad evaluation (Glass, 2015). It searches through a lot of articles published in both domestic and foreign periodicals. The impact of RME implementation on students' mathematical achievement was the focus of the study. The meta-analysis study is divided into multiple phases. The benefits of this approach include increased transparency, bias identification and minimization, better population parameter prediction, cross-domain analysis, significantly strong evidence, and rigorous methodology in the synthesis process (Glass, 2015). Seven steps for doing a meta-analysis study have been covered by a number of academic publications (Borenstein et al., 2009; Pigott, 2012). These steps are shown in Figure 1.

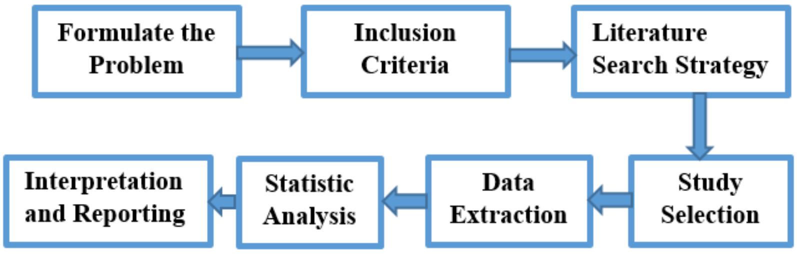

Figure 1. Flowchart of the Stages of the Meta-Analysis Method

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

Inclusion Criteria

A general and thorough preliminary investigation on the effect of RME implementation on students' mathematical achievement is still ongoing. PICOS (Population, Interventions, Comparator, Outcomes, and Study Design)-based inclusion criteria were developed to define the dimensions of the investigatory dilemma being examined in order to reduce the meta-analysis's scope. The requirements for participation in this research consist of the following descriptions:

1. The primary study's population consists of students.
2. The preliminary study's intervention was the use of the RME approach.
3. The output of the primary study is the students' mathematics achievement.
4. Primary studies are published in the period 2014-2023, in journals.

Only research articles addressing the implementation of realistic mathematics education, published in English within peer-reviewed journals from 2014 to 2023, were included in our study. We excluded conference proceedings, theses, reports, bibliographies, and other forms of "grey literature," as these sources are often considered to have lower quality and reliability (Nivens & Otten, 2017). The meta-analysis excluded primary studies that did not meet the inclusion criteria.

Literature Search Strategy

To support this meta-analysis, on February 8, 2024, we thoroughly searched six major academic databases for pertinent research articles: Scopus, ERIC, Sage Publications, Springer Publications, JSTOR, and Google Scholar. Three main factors led to the selection of Scopus as the main source of documents: it is acknowledged as the largest database for peer-reviewed literature (Niven & Otten, 2017), provides a wide variety of educational and social science literature, and upholds a consistent standard for document inclusion. Similar to this, academics continue to favor ERIC, Sage Publications, Springer Publications, JSTOR, and Google Scholar since they have been empirically proven to be very successful in identifying particular scientific works. In order to find pertinent research on the implementation of realistic mathematics education (RME), we created an inclusive search query that focused on keywords found in paper titles, abstracts, and abstracts. "Student mathematics achievement" and "realistic mathematics education implementation" were our two primary search terms for the databases we chose. Documents with titles, abstracts, or keywords matching these parameters were selected to ensure we captured key articles on RME deployment. Our search query was: TITLE-ABS-KEY ("realistic mathematics education implementation*" OR "student mathematics achievement*").

Study Selection

To achieve systematic identification, our document search adhered to the PRISMA criteria (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (see Figure 2).

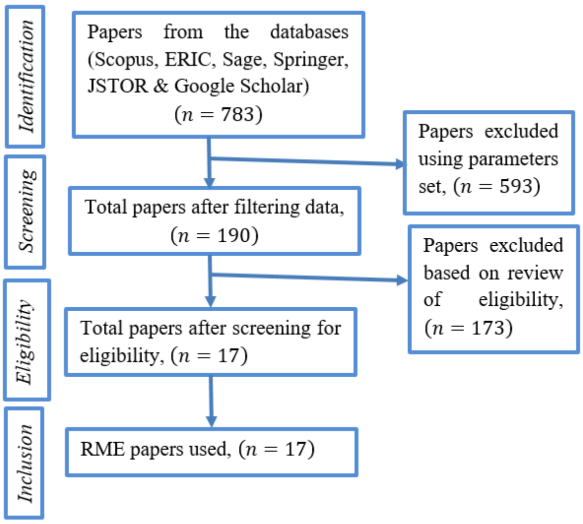

Figure 2. A Flow Chart Illustrating How PRISMA Was Used to Conduct a Meta-Analysis of An Experimental Investigation on RME

Source: Self – construct, 2024

According to Niven and Otten, (2017), the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analysis) procedure, the study selection process was divided into four steps: (1) *identification,* (2) *screening,* (3) *eligibility*, and (4) *inclusion*. After our document search, 783 documents were found in the chosen database and subsequently filtered. In the screening stage, we used inclusion criteria-based data cleaning filters. After removing 593 papers, 190 documents remained for eligibility examination. Each team member evaluated the title and abstract of each document during the eligibility stage, suggesting that certain items be kept or excluded. Following group discussions and additional examination of abstracts, titles, and occasionally entire texts, 173 documents were deemed irrelevant and excluded (Hallinger & Nguyen, 2022). The final dataset, which included 17 documents, was then ready for meta-analysis. Figure 2 shows the steps involved in choosing papers.

Data Extraction

Following the inclusion criteria and study selection phases, the researcher processed the data or information that was extracted, including the name of the author, statistical data (mean, standard deviation, sample size, t-value, and p-value), and the year of publication, to determine its validity and credibility. The results of a meta-analysis will be of superior quality if the data is reliable and valid.

Statistical Analysis

The effect size is the data that was examined in the meta-analysis (Glass, 2015). An indicator that measures the extent of the RME implementation effect is the effect size in this study. Although it permits a reasonable approximation, the Cohen equation seems to overstate the population number (Harwell, 2020). To rectify this overestimation, apply the Hedges' g equation. Consequently, Hedges' g equation is used to determine the effect size, and Cohen's et al.,(1988) classification serves as the basis for the interpretation. Since it does not assume that every study examined will produce the same accurate impact estimate, the estimating approach uses a random-effects model (Pigott & Polanin, 2020). Table 1 displays the impacts' classification based on Cohen et al., (1988).

Table 1. Effect Size Classification according to Cohen

Effect Size	Interpretation
0.00 – 0.20	Negligible
0.21 – 0.50	Small
0.51 – 1.00	Moderate
> 1.00	High

Since publication bias always affects study results, it is essential to examine sensitivity and publication bias in order to guarantee the validity of the statistical data in every important study (Budinski, & Milinkovic, 2017). To ensure that the results were not misrepresented, a publishing bias check was performed. The overall summary of reported effect sizes would indicate whether sample bias was present in any of the 17 studies that were included of the review (Borenstein et al., 2009). Filter plots, fill and trim tests, and the Rosenthal fail-safe N test were used to analyze publication bias (Harwell, 2020). Regarding the sensitivity analysis, the comprehensive meta-analysis

(CMA) software's "One study deleted" method was used. If the study shows a symmetrical distribution along the vertical line, it is considered bias resistant (Borenstein et al., 2009). Rosenthal's fail-safe N (FSN) statistic is applied when the impact size is not symmetrically distributed. This study is not susceptible to publishing bias if FSN/(5k+10)>1, where k is the number of papers that were part of the meta-analysis (Borenstein, et al., 2009). Both the fixed effect model and the random effect model are employed in the meta-analysis study (Borenstein, et al., 2009). 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).

Results

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

The Size of the Total Effect of Each Study

The degree of influence a treatment has is indicated by the extent of its effect. A meta-analysis of the impact of RME adoption on students' mathematical achievement serves as the link between factors in this case. A total of seventeen (17) papers were considered in this study's meta-analysis. Every paper was selected based on the predetermined inclusion criteria. The main objective of this study was to measure the overall effect of RME implementation on students' mathematical achievement. Eight (8) of the seventeen papers have moderate influence, eight (8) have high influence, and one has a minor but substantial effect. Table 2 displays the findings of the investigation.

Table 2. Effect Size Data of Papers

SN	Studies	Effect Size	Variance	Confidence Interval	
				Lower Limit	Upper Limit
1	Susanti et al. (2014a)	0.54	0.0104	0.34	0.74
2	Susanti et al. (2014b)	0.46	0.0104	0.26	0.66
3	Hirza et al. (2014)	0.85	0.0104	0.65	1.05
4	Zubainur et al. (2014)	0.84	0.0104	0.64	1.04
5	Wardono et al. (2016)	1.16	0.0104	0.96	1.36
6	Kusuma et al., (2016)	0.57	0.0800	0.03	1.11
7	Azmi et al., (2018)	1.69	0.0900	1.11	2.27
8	Nuraeni & Umber (2018)	1.17	0.0700	0.65	1.70
9	Umbara & Nuraeni (2019)	0.82	0.0700	0.32	1.32
10	Mahendra (2017)	1.47	0.0104	1.27	1.67
11	Habsah (2017)	2.07	0.0104	1.87	2.27
12	Fuzana et al., (2020)	0.52	0.0600	0.03	1.02
13	Saraseila et al., (2020)	0.79	0.0700	0.28	1.29

SN	Studies	Effect Size	Variance	Confidence Interval	
				Lower Limit	Upper Limit
14	Clement Ayarebilla Ali (2021)	1.15	0.0104	0.95	1.35
15	Cahyaningsih and Nahdi (2021)	2.62	0.0104	2.42	2.82
16	Ekowati et al. (2021)	0.72	0.0700	0.22	0.27
17	Ndanusa et al. (2023)	2.69	0.2300	1.75	3.64
Overall		**1.21**	**0.00104**	**1.15**	**1.27**

The magnitude of the impact of RME implementation on students' mathematical achievement is summed up in Table 2. As shown in Table 2, a total of seven studies have documented a strong positive effect of RME deployment on students' mathematical proficiency. With a 95% confidence level, the effect sizes found in the examination of 17 papers varied from 0.46 to 2.69. As a result, g = 1.21 was found to be the overall impact size of RME implementation on the students' mathematical achievement, suggesting a significant positive influence. Research supports this (Juandi et al., 2021).The results of the study show that using RME improves students' performance in mathematics. 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 3.

Table 3. Effect Size Transformation

Model	**Effect size**	**Standard Error**	Z	**95% Confidence Interval**		Q	**I² (%)**	$p-value$
				Lower Limit	**Upper Limit**			
Fixed Effect	1.2091	0.0322	37.6007	1.1460	1.2721	425.5267	96.24	0.001
Random Effect	1.1672	0.1732	6.7405	0.8278	1.5065			

Table 3 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 1.1460, and the upper limit is 1.2721. The study's overall effect size was 1.2091. This effect size is accepted as a High effect. In the random effect, the lower limit of the 95% confidence interval is 0.8278, and the upper limit is 1.5065. The study's overall effect size was 1.1672. This effect size is accepted as a high effect.

Heterogeneity Test

The next stage is to test for heterogeneity and choose an estimation model. Based on Table 4, the value of Q is 425.5267, 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 implementation significantly affects students' mathematics achievement compared to traditional learning. The degree of variation in effect size between studies is reflected in the I-squared value of 96.24%, which indicates that 96.24% 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 96.24%. Since the homogeneity test results were rejected, the estimation model used was a random-effect model. The random effects model provides a slightly lower and more conservative estimate of the pooled effect size.

Publication Bias

Next is to examine publication bias. The following is the funnel plot of the research in Figure 3.

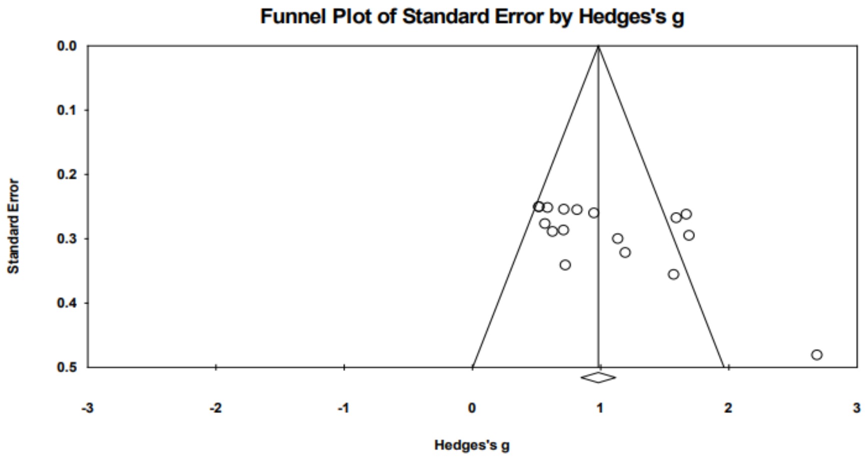

Figure 3. Funnel Plot Check for Publication Bias

It is evident from Figure 3 that the effect size spread is symmetrical around the vertical line. As a result, Figure 3 illustrates how the data distribution represented by the funnel plot is symmetrical. Rosenthal's Fail-Safe N (FSN) statistic was also looked at. The N value was determined to be 459 based on CMA calculations. According to Borenstein, et al. (2009), the calculation of 459 / ((5 x 17) + 10) yielded a result of 4.832 > 1. This number was found to be more than 1. This estimate suggests that the publication of their findings did not distort the research that was analyzed. This aligns with the finding that symmetric data dispersion is depicted by the funnel plot (Fadhli, 2020; Juandi et al., 2021). Publication bias does not affect the papers that are part of this study. Because of publication bias, no studies were excluded or required to be included in the analysis.

Calculating the P-Value

Finding the p-value to test the study hypothesis is the final stage. The analysis's findings are contrasted using the estimating model in Table 4. Based on Table 4, the random effect model shows that the study's overall effect size is 1.1672, and the 95% CI runs from 0.8278 to 1.5065, meaning that the mean difference can fall anywhere within this range. As a strong effect, this effect size is acceptable. The Z score was 6.7405 after the Z test was computed to ascertain statistical significance. At the level of $p < 0.001$, this result can be considered statistically significant. Thus, realistic mathematics Education implementation has a more substantial influence on students' mathematics achievement than traditional learning models.

Moderator Variables

17 effect sizes from 17 primary studies is then examined in order to assess the degree of study characteristics. A summary table of subgroup analyses based on three moderator variables—sample size, educational stage, and geographic location—is presented in Figure 4 along with a meta-analytic forest plot. Examining the variation (heterogeneity) in effect sizes among various research attributes is the aim. The moderator variables, which include sample size (≤30 or ≥31), educational level (Primary, JHS, SHS), and setting (rural or urban), demonstrate how the studies are grouped. The accuracy of the effect size estimate is shown by the SE (Standard Error). More precision is indicated by a lower SE.

The null hypothesis, according to which the genuine effect is zero, is tested by the Z-score. A stronger influence is indicated by a higher absolute Z. The Cochrane Q test, which tests for heterogeneity, determines whether the effect sizes differ more than would be predicted by chance. More heterogeneity is indicated by a higher Q-value. Figure 4 shows a forest plot at the bottom, with each blue square denoting the effect size (Hedges' g) for a group. The effect size's 95% confidence interval (CI) is displayed by the horizontal lines that emerge from the squares. No influence is indicated by the vertical dashed line at 0. At the 95% confidence level, a result is not statistically significant if a confidence interval crosses this threshold. Groups are labeled (e.g., ≤30, ≥31) to correspond to their entries in the table.

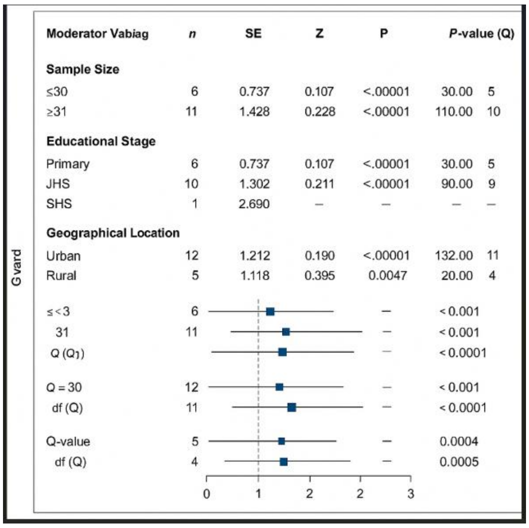

Figure 4. Displays a Meta-Analytic Forest Plot alongside a Summary Table of Subgroup

Figure 4 shows a moderate effect with a sample size of ≤30 (n = 6) and an effect value of 0.737 with a low SE (0.107). Significant heterogeneity (Q = 30, p <.001) indicates that the impacts differ within this subgroup. This outcome is consistent with Tamur et al. (2021). Lower precision is indicated by a slightly larger effect size with a wider confidence interval (CI) when the sample size is ≥31 (n = 11) demonstrates notable heterogeneity as well (Q = 110, p <.001). The primary education level (g = 1.302) and junior high (g = 0.737) exhibit large and moderate impacts, respectively, with acceptable SE and significant p-values, for the moderating variables related to students' educational stage. Since SHS (n = 1) only has one study, no test statistics nor heterogeneity are computed (Z and P are not provided). There is no discernible variation in the impact of RME implementation on students' mathematical achievement according to educational stage, indicating that the impact of RME implementation on students' mathematical achievement is not influenced by educational stage. This is because the p-value > 0.05 and the distribution of effect sizes for the three categories of the study characteristics are homogeneous. The RME strategy is more successful at the primary school level, according to study (Tamur, 2020) that looks at how RME adoption affects students' critical thinking abilities. Research from both urban (n = 12, g = 1.212) and rural (n = 5, g = 1.118) settings revealed moderate to strong impact sizes for the student geographical location moderator variable. Studies conducted in urban areas are more heterogeneous (Q = 132, p <.001) than those conducted in rural areas (Q = 20, p <.005), indicating that effects vary more in urban environments. The distribution of effect sizes for both categories on the demographic location study characteristics of the students is varied, as indicated by the p-value < 0.05. Therefore, it can be inferred that the demographics of the students under study have an impact on the impact of RME implementation on students' mathematical achievement because there is a notable variation in this effect depending on the demographic location of the students. According to this study (Tamur et al., 2020), the variability of the effect sizes was considerably impacted by the demographic traits of the students. It may be inferred that the application of RME would have the greatest impact on students' proficiency in mathematics, particularly in urban settings. Lastly, this analysis demonstrates that statistically significant impact sizes are consistently demonstrated across subgroups. Significant heterogeneity is noted, too, especially in metropolitan areas and bigger samples, indicating that additional variables might affect the results.

Discussion

This meta-analysis sought to address several key research questions regarding the impact of Realistic Mathematics Education (RME) on students' mathematics achievement. The findings underscore the significance of RME as a pedagogical approach and reveal important insights into how various factors influence its effectiveness.

Overall Effect of RME Implementation

The first research question attempted to establish the overall effect of RME deployment on students' mathematical achievement. A significant positive influence was indicated by the analysis, which produced a significant effect size of Hedges' g = 1.21 with a 95% confidence interval of [1.15, 1.27]. Research supports this (Juandi et al., 2021). The study's findings indicate that the RME adoption enhance students' mathematics achievement. According to this finding, students who were exposed to RME fared more than one standard deviation better than their peers in conventional classroom environments. RME can be an effective tool for improving mathematics learning outcomes, as evidenced by its substantial impact size, which is consistent with Cohen's et al., (1988) description of a significant educational intervention. This finding is consistent with previous research indicating that RME fosters deeper understanding and application of mathematical concepts (Gravemeijer & Doorman, 1999).

Effect Size and Sample Size

The second research question examined whether the effect size of RME implementation varies with sample size and found that studies with smaller sample sizes (≤30) reported larger effect sizes (g = 1.428) than studies with larger sample sizes (≥31), which had an effect size of g = 0.737. This finding is consistent with Tamur et al. (2020) and suggests a possible small study effect, where smaller studies may report more pronounced impacts due to various biases, such as publication bias or methodological differences. This phenomenon is well-documented in the literature, where smaller studies often produce more optimistic results (Borenstein et al., 2009), and future research should take this into account when interpreting results.

Effect Size and Educational Level

The third research question investigated if the students' educational attainment affected the impact size of RME adoption. The results showed that RME worked best in the junior high (g = 0.737) and primary education levels (g = 1.302). The RME strategy is more successful at the elementary school level, according to study (Tamur et al, 2020) that looks at how RME adoption affects students' critical thinking abilities. This implies that while younger students are still learning the fundamentals of mathematics and could gain a great deal from contextualized learning experiences, they might be more open to RME's practical applications (Harwell, 2020). As students' progress to higher educational levels, their prior knowledge and cognitive development may influence the efficacy of RME, indicating a need for tailored instructional strategies that accommodate varying developmental stages.

Effect Size and Geographical Distribution

The last research question investigated the differences in the effect size of RME implementation depending on the geographic distribution of the studies. According to the study, impact sizes in urban studies were marginally larger (g = 1.212) than in rural research (g = 1.118). Disparities in teacher preparation, educational resources, and student engagement between urban and rural environments may be the cause of this discrepancy. According to Caraan et al., (2023), urban schools frequently have easier access to instructional resources and professional development opportunities, which could improve the implementation of RME. According to this conclusion, RME could need to be modified to suit the particular difficulties experienced by educators in rural areas. It also emphasizes the significance of context in educational interventions.

Conclusions and Implications

This meta-analysis provides robust evidence supporting the effectiveness of Realistic Mathematics Education (RME) in enhancing students' mathematics achievement. The findings not only affirm the positive impact of RME but also highlight several important implications for theory, practice, and future research.

Theoretical Implications

The results contribute to the existing body of literature on mathematics education by reinforcing the theoretical frameworks that underpin RME. Specifically, the significant effect size supports constructivist theories, which advocate for learning environments that promote understanding through real-world applications and contextualized problem-solving (Piaget, 1970; Vygotsky, 1978). By demonstrating that RME can lead to substantial improvements in student outcomes, this study adds empirical support to the notion that students learn mathematics more effectively when they engage with meaningful contexts. Furthermore, the variations in effect sizes based on educational level and geographical context suggest that theories of learning and instruction must account for these factors, encouraging a more nuanced understanding of how educational interventions can be tailored to diverse student populations.

Practical Implications

The findings have significant practical implications for educators and policymakers. Given the large overall effect size, educators are encouraged to adopt RME as a viable instructional approach in mathematics classrooms. The results indicate that RME is particularly effective at the primary education level, suggesting that early implementation may yield the greatest benefits. Additionally, the differences in effect sizes based on sample size and geographical distribution underscore the importance of context in instructional design. Teachers in urban settings may benefit from enhanced resources and training, while rural educators might require additional support to effectively implement RME. Policymakers should consider these factors when developing curricula and investing in teacher professional development, ensuring that all educators have access to the tools and training necessary to implement RME successfully.

Further Studies

Future research should aim to build on the findings of this meta-analysis by exploring several key areas. First, longitudinal studies could provide insight into the long-term effects of RME on students' mathematical understanding and retention. Additionally, qualitative research exploring the experiences of teachers and students in RME classrooms could yield valuable information about the challenges and successes associated with its implementation. Researchers should also investigate the specific elements of RME that contribute most significantly to its effectiveness, potentially identifying best practices for instructional design. Furthermore, studies that examine the impact of RME across different cultural and educational contexts would enhance the generalizability of the findings, contributing to a more comprehensive understanding of how RME can be adapted to meet the needs of diverse learners. In conclusion, this meta-analysis demonstrates that RME has a significant and positive impact on students' mathematics achievement. By addressing theoretical, practical, and future research implications, this study paves the way for continued exploration and application of effective mathematics education strategies.

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