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The Effects of Realistic Mathematics Education on Mathematics Attitudes of Students Studying in Turkey: A Meta-Analysis

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ABSTRACT

In this research, the effects of Realistic Mathematics Education on the mathematics attitudes of students studying in Turkey were investigated through meta-analysis. For this purpose, determined indexes were searched for relevant keywords. As a result of the searching, 22 studies were included in the research according to the predetermined inclusion criteria and their effect sizes were calculated. In the analysis, the statistics programs MetaWin and Comprehensive Meta-Analysis were employed. The effect sizes were calculated using Hedges' g coefficient, with a 95% confidence level. The overall effect size value was calculated as 0.652 with a 0.101 level of standard error using the random effects model. The findings show that Realistic Mathematics Education has a moderately positive effect on the attitudes of students studying in Turkey toward mathematics. The effect sizes calculated with regard to moderator variables -level of education, field of study and implementation period-, revealed no statistically significant differences between the groups. There was a statistically significant difference in sample size between the groups.

Keywords: Attitude, meta-analysis, Realistic Mathematics Education.

Gerçekçi Matematik Eğitiminin Türkiye'de Öğrenim Gören Öğrencilerin Matematik Tutumlarına Etkisi: Bir Meta-Analiz

ÖZ

Bu araştırmada Gerçekçi Matematik Eğitiminin Türkiye'de öğrenim gören öğrencilerin matematik tutumlarına etkisi meta-analiz yoluyla araştırılmıştır. Bu amaçla ilgili anahtar kelimelerle belirlenen indeksler taranmıştır. Tarama sonucunda önceden belirlenmiş dahil etme kriterlerine göre 22 çalışma araştırmaya dahil edilmiş ve etki büyüklükleri hesaplanmıştır. Analizde MetaWin ve Comprehensive Meta-Analysis istatistik programları kullanılmıştır. Etki büyüklükleri hesaplanırken güven düzeyi ise %95 olarak kabul edilmiş ve Hedges's g katsayısı kullanılmıştır. Genel etki büyüklüğü değeri, rastgele etkiler modeli kullanılarak 0.101 standart hata düzeyinde 0.652 olarak hesaplanmıştır. Bulgular, Gerçekçi Matematik Eğitiminin Türkiye'de öğrenim gören öğrencilerin matematiğe yönelik tutumları üzerinde orta düzeyde olumlu bir etkiye sahip olduğunu göstermektedir. Eğitim düzeyi, çalışma alanı ve uygulama süresi gibi moderatör değişkenlere göre hesaplanan etki büyüklükleri bakımından gruplar arasında istatistiksel olarak anlamlı bir farklılık olmadığı, örneklem büyüklüğü bakımından ise gruplar arasında istatistiksel olarak anlamlı bir farklılık olduğu belirlenmiştir.

Anahtar kelimeler: Tutum, meta-analiz, Gerçekçi Matematik Eğitimi.

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1 | INTRODUCTION

Mathematics, which is an important tool to understand the world, has an active role in shaping the future of individuals and societies. Individuals who are successful in mathematics have more opportunities with regard to education, business life and social status (Kilpatrick & Swafford, 2003; National Council of Teachers of Mathematics [NCTM], 2000; Organisation for Economic Co-operation and Development [OECD], 2013). Everyone needs mathematical calculations and analysis in their daily life (Haylock & Thangata, 2007; Kilpatrick et al., 2001). Therefore, it can be stated that all one needs to gain basic mathematical skills to meet their mathematical needs in the natural flow of their lives.

Mathematics is taught at all stages of education, from primary to higher education. NCTM (2000) stated that essential opportunities and support should be provided at schools for all children to understand and learn mathematics in depth. Mathematics, a part of modern life and creative discipline, equips children with powerful tools such as abstract thinking, logical reasoning and problem-solving skills which are necessary to understand life and change the world (Department for Education and Employment [DfEE], 1999). The primary goal of mathematics instruction is to prepare students to deal with the mathematical demands of everyday life, to acquire fundamental numerical knowledge and abilities, and to build mathematical thinking skills that will help them increase their intellectual ability (Haylock & Thangata, 2007). Therefore, individuals need to build mathematics through exploration, reasoning, problem-solving, discussion and practical experiences (Haylock, 2010). Individuals who learn mathematics only as procedures cannot use and apply it to their real lives, except in situations similar to what is taught (Davis et al., 2017). Thus, rather than allowing students to passively absorb information, instruction should be based on their prior knowledge, and teachers should assist students in constructing mathematical knowledge (Carpenter et al., 1999). Teachers should instruct students on how to study mathematics, think mathematically, and discover mathematics on their own (Lappan, 1999). Therefore, it can be stated that teachers should avoid traditional teaching approaches that present a mathematical concept including all procedures for its solution step-by-step (Chapko & Buchko, 2004). Instead, teaching strategies which attract the attention of children, challenge children mathematically, and show that children's mathematical ideas are valued should be used (Lappan, 1999).

REALISTIC MATHEMATICS EDUCATION

The Freudenthal Institute in the Netherlands developed Realistic Mathematics Education (RME) as a reform movement against traditional mathematics education (De Lange 1996; Van den Heuvel-Panhuizen & Wijers, 2005; Van den Heuvel-Panhuizen & Drijvers, 2014). Freudenthal's view of mathematics as a human activity is the cornerstone of the RME (Freudenthal, 1991). According to RME, various and realistic experiences should be a part of the learning process. Students use these experiences to begin developing mathematical ideas, tools, and processes (De Lange 1996; Van den Heuvel-Panhuizen & Wijers 2005; Van den Heuvel-Panhuizen & Drijvers, 2014). RME emphasizes increasing students' mathematical understanding and motivation (Freudenthal, 1991; Gravemeijer, 1994). It includes views on what mathematics is, how it should be taught, and how students learn mathematics (Zulkardi, 2002). Students should be given the opportunities to explore mathematics by organizing mathematical relationships and processes in real-world experiences or experiences that are important to them, and they should not be thought of as passive receivers of mathematical knowledge (Freudenthal, 1991). In this way, under the guidance of the teacher, formal mathematical knowledge can be created from the students' informal knowledge (Treffers, 1991). Learning mathematics means doing mathematics by solving daily life problems (Gravemeijer, 1994). Mathematics is formalized with axioms in its final stage. Axioms should not be the starting point in teaching mathematics. Teaching mathematics should be structured as a guided reinvention process in which students can follow in the footsteps of mathematicians (Freudenthal, 1991).

Previously stated, mathematics is a human activity according to RME, Freudenthal (1991) describes this activity as problem solving, problem searching, and also organizing a topic. He stated that in order to solve the problem, it should be structured according to mathematical patterns, organized according to new ideas in a larger framework or with an axiomatic way. This organizing activity is called mathematization (Gravemeijer, 1994; Treffers, 1991). Freudenthal (1991) stated that mathematization provides students with the opportunity to approach daily life situations mathematically, and therefore is a key process in mathematics teaching. It is aimed to develop knowledge from students' thoughts in the mathematization process, the process should be started by mathematizing the problems that related to their daily lives (Fauzan, 2002). In this way, students have the opportunities to solve real-life problems using their informal knowledge. This process refers to horizontal mathematization (Treffers, 1991). As students experience similar processes, they acquire more formal knowledge and algorithms. This process also refers to vertical mathematization (Treffers, 1991). Horizontal mathematization, according to Freudenthal, entails going from the real world to the world of symbols, and vertical mathematization entails moving inside the world of symbols (Freudenthal, 1991). De Lange (1987) stated that horizontal mathematization involves transferring the real world situation to a mathematical one. Horizontal mathematization tasks include formulating and visualizing a problem in many ways, as well as exploring relationships and patterns. Vertical mathematization tasks include expressing a connection with a formula, utilizing multiple models and combining models, generating a new mathematical idea, and generalizing (De Lange, 1987). The horizontal and vertical processes of mathematization are inextricably linked, with no clear distinction between them (Freudenthal, 1991). Highlighting only real-life situations can push the vertical math process into the background (Van den Heuvel-Panhuizen & Drijvers, 2014). The long-term learning process in RME is created through horizontal and vertical mathematization procedures. Students build formal mathematics through mathematizing real-life problems (horizontal) and problem-solving procedures (vertical). (Fauzan, 2002).

TEACHING PRINCIPLES OF RME

RME has basic principles although it has a dynamic structure. These principles can be listed as follows (Van den Heuvel-Panhuizen & Wijers 2005; Van den Heuvel-Panhuizen & Drijvers, 2014):

The activity principle points out that students are active participants in the learning process. Students build their own mathematics skills and understanding. Mathematics is a human activity that is best taught via practice.

The reality principle means that mathematics instruction should begin with problems which students can make sense of. While solving these problems, students develop informal solving strategies and have the opportunity to make sense of the mathematical structures they have developed. Teaching begins with rich context problems that require mathematical organization rather than teaching definitions and abstractions. Students can develop mathematical understanding while studying on these problems.

The level principle reflects various levels of learning that students go through while learning mathematics such as creating shortcuts and diagrams, developing informal solving strategies, and learning about the relationships between concepts and strategies. In this process, models are effective in filling the gap between informal and formal mathematics.

The intertwinement principle denotes that mathematical topic areas should not be viewed as separate elements of the curriculum, but rather as a cohesive whole. Mathematics is divided into fields that are inextricably linked, and these fields are taught in tandem.

The interaction principle implies that learning mathematics is both an individual and a social activity. Students' explorations and strategies should be shared with others in class and group discussions, and opportunities to contribute their thoughts and opinions should be provided. As a result, students will be able to get insight into how to develop their strategies and achieve a higher degree of comprehension.

The guidance principle represents the guided reinvention of mathematics. Teachers and the curriculum both play a proactive role in the learning of students. Teachers must provide a learning environment in which students can participate in the construction of mathematics. Mathematical scenarios should also be included in the curriculum so that students can explore mathematics depending on the goals of mathematics education.

The principles described should be taken into account while designing and implementing an RME-based teaching approach (Treffers, 1991).

ATTITUDE TOWARDS MATHEMATICS

Neale (1969, p.632) defined attitude towards mathematics as "a collective measure of liking or disliking mathematics, a tendency to participate in or avoid mathematical activities, a belief that one is good or bad in mathematics, and a belief that mathematics is beneficial or useless". Attitude towards mathematics is one of the factors that affect students' mathematical performance (Lipnevich et al., 2011). It is stated that students who have a positive attitude towards mathematics are more successful in mathematics (Nicolaidou & Philippou, 2003; Sanchez et al., 2004). According to Ma and Kishor (1997), there is a positive relation between mathematics attitude and mathematics performance, and negative attitudes contribute to worse mathematics performance. Students must have a strong knowledge of fundamental mathematical ideas and a positive attitude toward mathematics study in order to be able to use mathematics successfully in their life and be successful further mathematics (Kilpatrick & Swafford, 2003). Teacher and teaching are two elements that have an effect on students' attitudes towards mathematics (Fraser & Kahle, 2007; Hourigan et al., 2016). Therefore, it can be stated that the teaching approaches offered to students affect students' attitudes towards mathematics.

THE PRESENT RESEARCH

Many studies have investigated at the effect of RME on students' attitudes toward mathematics (e.g. Çilingir & Dinç Artut, 2016; Fauzan, 2002; Hough et al., 2017; Korkmaz & Tutak, 2017; Korkmaz & Korkmaz, 2017; Özkaya & Yetim Karca, 2017; Üzel & Mert Uyangör, 2006; Zakaria & Syamaun, 2017; Zulkardi, 2002). In these studies, the effects of RME with regard to various variables such as student groups at different education levels, different sample sizes, different implementation periods and sub-fields of mathematics were examined. While similar results were obtained in some of these studies conducted independently from each other, different results were obtained in others. Thus, bringing together the mentioned research findings and creating a synthesis will lead the way to draw a conclusion and making generalizations of the results. There is no meta-analysis research assessing the effect of RME on the mathematics attitudes of students studying in Turkey in the literature. Based on this, it is aimed to do a meta-analysis of experimental studies investigating the effects of RME on the mathematics attitudes of students studying in Turkey.

RESEARCH QUESTIONS

The following research questions were intended to be answered for this purpose:

1. What is the overall effect of RME on the mathematics attitudes of students studying in Turkey?
2. How does the overall effect of RME on attitude differ with regard to level of education?
3. How does the overall effect of RME on attitude differ with regard to field of study?
4. How does the overall effect of RME on attitude differ with regard to implementation period?
5. How does the overall effect of RME on attitude differ with regard to sample size?

2 | METHOD

RESEARCH DESIGN

Meta-analysis method was used in the research. With meta-analysis, quantitative data obtained as a result of individual studies on a particular topic are brought together, statistical analysis of these data are made and a general evaluation is reached (Durlak & Lipsey, 1991; Glass, 1976; Lipsey & Wilson, 2001; Sánchez-Meca & Marín-Martínez, 2010). In order to reduce the limitations of individual studies with meta-analysis, all studies on the topic are brought together and the results of these studies are synthesized using statistical tools (Frankel et al., 2012). In this context, overall effect sizes for individual studies are defined and the relationships between these effect sizes are interpreted (Card, 2012). Effect size is a value that reflects the size of the result occurring between the groups in an experimental implementation and the degree of the relationship between two variables (Borenstein et al., 2009; Ellis, 2010). The effect size is used to standardize the evaluation results (Mertens, 2010).

After the problem is determined in the meta-analysis process, the relevant literature is investigated in detail and all possible studies are found. Consistent criteria are developed for the discrimination of the studies reached and these studies are coded according to the determined criteria. The results are interpreted by statistical analysis of the data recorded as a result of coding (Neuman, 2013; Sánchez-Meca & Marín-Martínez, 2010). These steps were followed in the present meta-analysis study.

DATA COLLECTION

The data of this research were collected during July in 2021. The data source is constituted by studies that examined the effects of RME on students' mathematical attitudes in Turkey. In order to reach the studies, "Realistic Mathematics Education, RME" keywords in both Turkish and English were searched on the indexes Web of Science (WoS), Education Resources Information Center (ERIC), Google Academic, TR Index and Council of Higher Education Thesis Center. As a result, a total of 106 scientific studies were reached, including 33 articles and 73 postgraduate theses. It was determined that some of the articles were reproduced from postgraduate theses. For this reason, the related theses were not included in the analysis, instead articles were included. The studies that would be included in the meta-analysis were specified based on the following criteria:

1. The study must be conducted in Turkey and either in Turkish or English.
2. The study must be conducted in 2021 and before.
3. The study must have an experimental research design (experimental and control groups with pretest-posttest).
4. In the study, there must not be a statistically significant difference between the pre-test attitude scores of the experimental and control groups, the groups must be homogeneous with regard to attitude.
5. In the study, information about the validity and reliability of measurement tools that used to measure mathematics attitude must be stated.
6. In study, the experimental groups must be taught with RME and the control groups must be taught with the mathematics program specified in the national curriculum in the relevant year.
7. The study must be open to access in indexes which are WoS, ERIC, Google Academic, TR Index and Council of Higher Education Thesis Center.
8. The study must include statistical values (pretest-posttest attitude scores, standard deviation, sample size, p value, t value, F value) related to the experimental and control groups required for the calculation of the effect size.

Considering the inclusion criteria, 22 studies were included in this meta-analysis. One of these studies used two control groups therefore two separate effect size values were calculated and presented in forest plot with labels a and b next to the year of the studies.

DATA CODING

A coding form that containing the information about the studies was prepared by the researcher taking into consideration inclusion criteria. The information included in the form is: title of the study, year, author, type of the study, education level of the sample, field of the study, implementation period, sample size, arithmetic mean and standard deviation values of the experimental and control groups. Coding was processed by the researcher based on this information. In order to ensure coding reliability, two weeks after the first coding, the researcher recoded using the same form. By comparing the two coding results, it was determined that there was no difference and the analysis phase was started.

Descriptive statistics of the studies included in the meta-analysis are presented in Table 1.

Table 1. Sample Descriptive Statistics of the Studies Included in the Meta-analysis

		Frequency (f)	Percentage (%)
Type of Study	Article	6	27.27%
	Master's Thesis	14	66.64%
	Doctoral Dissertation	2	9.09%
Year of the Study	2007	1	4.54%
	2008	1	4.54%
	2010	1	4.54%
	2011	1	4.54%
	2012	1	4.54%

	2014	2	9.09%
	2015	1	4.54%
	2016	1	4.54%
	2017	4	18.18%
	2018	1	4.54%
	2019	6	27.27%
	2020	2	9.09%
Education Level of the Sample	Primary School	7	31.81%
	Middle School	12	54.54%
	High School	3	13.63%
Sample Size	1-15 participants	1	4.54%
	16-30 participants	14	63.63%
	31-45 participants	5	22.72%
	46-60 participants	2	9.09%
Field of Study	Mathematics	16	72.72%
	Geometry	6	27.27%
Implementation Period	1-5 periods	1	4.54%
	6-10 periods	4	18.18%
	11-15 periods	6	27.27%
	16-20 periods	6	27.27%
	36-40 periods	1	4.54%
	Not specified in periods	4	18.18%
Total		22	100

Table 1 reveals that 6 (27.27%) of the studies are articles, 14 (66.64%) master's theses, and 2 (9.09%) doctoral dissertations. Most of the studies were conducted in 2019 (f=6, 27.27%). With regard to education level, mostly middle school (f=12, 54.54%) and primary school (f=7, 31.81%) were sampled and the sample size was mostly 16-30 participants (f=14, 63.63%). 16 of the studies (72.72%) were related to mathematics, and 6 of them (27.27%) were related to geometry. Four of the studies (18.18%) did not specify the period of implementation.

DATA ANALYSIS AND INTERPRETATION

In meta-analysis, two fundamental approaches to calculating effect sizes are used namely fixed effects model and random effects model (Borenstein et al., 2009; Hunter & Schmidt, 2004). In the fixed effects model, the effect sizes of all studies to be included in the meta-analysis are assumed not to change, and the standard deviations of the studies are assumed to be zero. The random effects model, on the other hand, assumes that the effect sizes of all studies to be included in the meta-analysis differ from study to study, and the standard deviations of the studies are assumed to be different from zero (Ellis, 2010). There are techniques used to decide which model to prefer. One of them looks at the Q statistics, which indicates whether the effect sizes are heterogeneously distributed. The Q statistic tests the null hypothesis, which states that all studies included in the meta-analysis share a common effect size with the chi-square (χ^2) distribution. Thus, if the calculated Q value is smaller than the chi-square critical value according to the significance level (p value) and degrees of freedom (df), the distribution is considered homogeneous, and if it is greater, it is considered heterogeneous (Borenstein et al., 2009). As a result of the Q-statistic, the fixed effects model is preferred when the distribution is homogeneous, and the random effects model is preferred when it is heterogeneous (Ellis, 2010). In addition, Borenstein et al. (2009) recommends to use of random effects model when the studies to be included in the meta-analysis are selected from published literature. In the present research, the studies to be included in the meta-analysis were selected from the published literature, and the Q statistic was considered to determine the model to be employed.

Hedges' g coefficient, which indicates the corrected and standardized mean difference between groups (Borenstein et al., 2009), was used in the calculation of effect sizes, and the confidence level was assumed to be 95% in the analysis. In interpreting the effect sizes, the criteria proposed by Cohen et al. (2007, p. 521), "weak effect between 0-0.20, modest effect between 0.21-0.50, moderate effect between 0.51-1.00, strong effect 1 and above" was used.

MetaWin software was used to examine normal distributions of effect sizes, while Comprehensive Meta-Analysis (CMA) was used for other analysis. In the calculations, via the interfaces provided by CMA, mean (M), standard deviation (SD), sample size (N) values and test statistics values (p value, t value, F value, etc.) of the experimental and control groups were used. As mentioned earlier, level of education, field of study, implementation period and sample size were specified as moderator variables in this study. Funnel plot and Rosenthal's Safe-N statistic (Fail-Safe N-FSN) (Borenstein et al., 2009) were used together in determining the publication bias of the studies to be included in the meta-analysis. In addition, the formula N/(5k+10) (k refers to the number of studies included in the meta-analysis) proposed by Mullen et al. (2001) based on Rosenthal's fail-safe N was used. The value obtained as a result of the calculation according to this formula greater than one indicates that the meta-analysis result is sufficiently resistant to publication bias.

RESEARCH ETHICS

In this research, the data were collected from open access and published studies. Scientific ethics and publication ethics norms were followed at every stage of the research.

3 | FINDINGS

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The normal distribution chart was examined to determine if it was possible to combine the effect sizes of the studies with meta-analysis. Figure 1 shows the normal distribution chart.

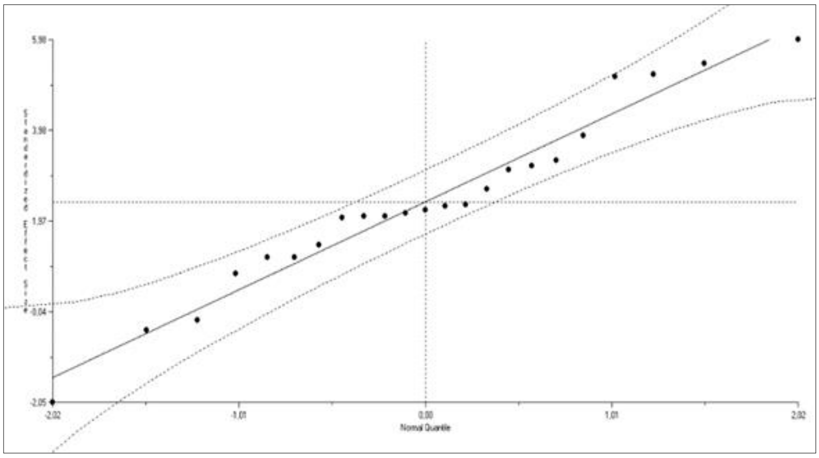

Figure 1. *Normal Distribution Chart*

The effect sizes of the studies included in the meta-analysis were scattered around the normal distribution line and within the confidence range given with dashed lines, as illustrated in Figure 1. On this basis, it can be assumed that the effect sizes are normally distributed and can be statistically combined with the meta-analysis.

The publication bias of the studies included in the meta-analysis was examined using a funnel plot. The funnel plot is shown in Figure 2.

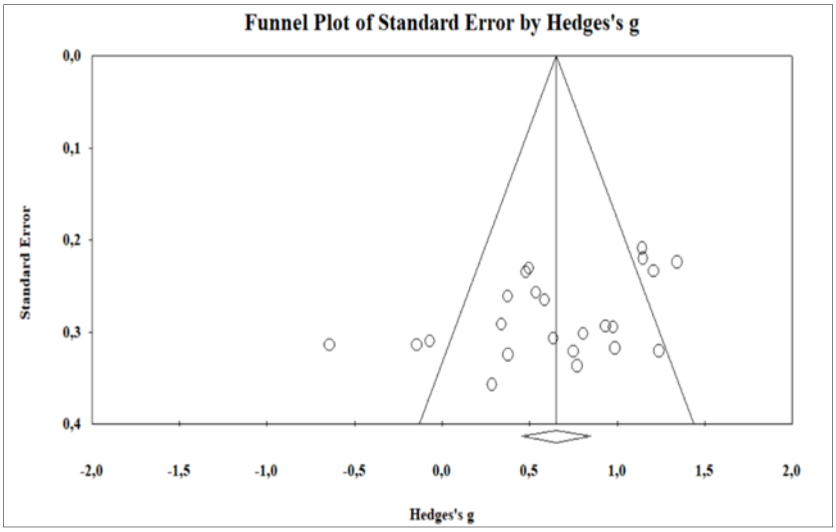

Figure 2. *Funnel Plot of Effect Sizes*

The effect sizes were generally collected in the centre of the funnel plot and scattered asymmetrically on either side of the vertical line indicating the combined effect size, as shown in Figure 2. This finding suggests that the possibility of publication bias exists. Therefore, both Rosenthal's fail-safe N (FSN) formula and Mullen et al.'s N/(5k+10) formula were used to investigate publication bias.

Rosenthal’s FSN Results are presented in Table 2.

Table 2. Rosenthal’s FSN Results

Bias Level	
Observed studies' Z-value	11.45481
Observed studies' p-value	0.00000
Alpha	0.05
Tails	2
Alpha's Z	1.95996
Observed studies' number	23
FSN	763

The FSN value is calculated as 763 as seen in Table 2. This value indicates the number of studies required for the overall effect size calculated as a result of meta-analysis to be statistically insignificant, with a p value greater than alpha. Furthermore, the value [763/(5*23+10)=6.10>1] resulting from the formula N/(5k+10) suggests that the studies included in the meta-analysis are sufficiently resistant to publication bias.

The statistical results of the studies calculated according to the two approaches are presented in Table 3 to decide which model to use for further calculations.

Table 3. Statistical Findings of Studies Calculated based on the Effect Models

Model	*ES*	%95 CI for *ES* Lower Limit	Lower Limit	*SE*	*df*	*Q*	χ^2	*p*
Fixed	0.699	0.586	0.811	0.057	22	66.225	33.924	0.000
Random	0.652	0.455	0.849	0.101				

According to the fixed effects model, the homogeneity value of the studies included in the meta-analysis is Q=66.225 as shown in Table 3. At the 95% significance level, the chi-square critical value for 22 degrees of freedom is 33.924. The calculated Q value is greater than the chi-square critical value, and the p value is significant ($p<.05$) indicates that the studies have heterogeneous structure. Based on this, random effects model was used in statistical calculations.

Table 3 shows the findings of the research's first question, "What is the overall effect of RME on the mathematics attitudes of students studying in Turkey?". The overall effect size value was calculated as 0.652 with a standard error of 0.101 with regard to the random effects model. The calculated effect value is moderate as stated by Cohen et al. (2007). On this basis, it can be concluded that RME has a moderate effect on mathematics attitude. In addition, the positive sign of the effect value shows that RME has a favourable effect on mathematics attitude.

Figure 3 shows a forest plot the distribution of effect size values calculated using the random effects model.

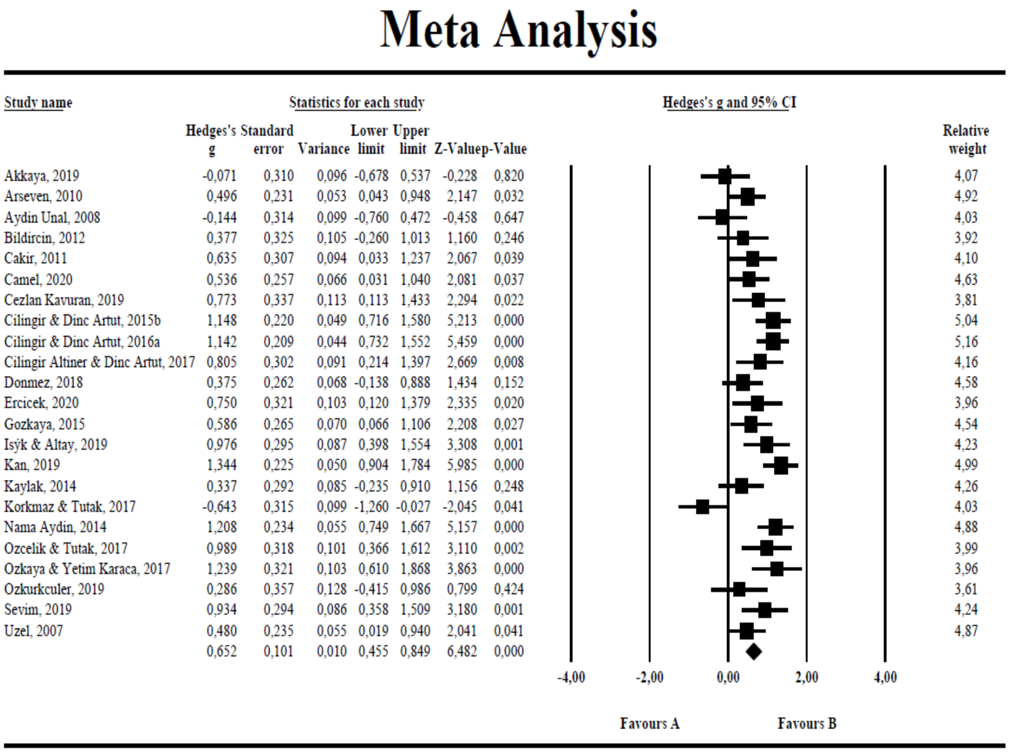

Figure 3. *Forest Plot of the Effect Sizes*

The effect size of each study is represented with the black squares in Figure 3, and the lines on both sides of the squares indicate the upper and lower limits of the calculated effect size in a 95% confidence interval (CI). The area of the squares shows the effect of the related study on the overall effect size. In addition, the rightmost column of the figure contains numerical values for the studies' weight. The calculated overall effect size is represented by the rhombus at the bottom. In accordance with the calculated effect sizes, the smallest effect size is -0.643, while the largest effect size is 1.344. There are 20 positive and three negative effect sizes. Accordingly, in 20 studies, RME has a favourable effect on the experimental group.

Table 4 shows the findings of the research's second question "How does the overall effect of RME on attitude differ with regard to level of education?".

Table 4. Statistical Findings of Studies Calculated based on the Effect Models

Moderator	Q_B	*p*	*df*	*n*	*ES*	%95 CI for *ES*		*SE*
						Lower Limit	Upper Limit	
Level of Education	4.275	0.118	2					
Primary school				8	0.902	0.630	1.174	0.139
Middle school				12	0.522	0.249	0.795	0.139
High school				3	0.488	-0.074	1.051	0.287

As shown in Table 4, the homogeneity value between the groups calculated with regard to the level of education is Q_B=4.275. At the 95% CI level, the chi-square critical value for 2 degrees of freedom is 5.991. The Q_B value is smaller than the chi-square critical value, and the p value is not significant (p>.05). Thus, it can be stated that RME teaching does not reveal a significant difference in the level of education between the groups.

Table 5 shows the findings of the research's third question "How does the overall effect of RME on attitude differ with regard to field of study?".

Table 5. Effect Sizes Calculated with regard to Field of Study

Moderator	Q_B	*p*	*df*	*n*	*ES*	%95 CI for *ES* Lower Limit	%95 CI for *ES* Upper Limit	*SE*
Field of Study*	0.123	0.726	1					
Mathematics				16	0.676	0.463	0.890	0.109
Geometry				7	0.586	0.129	1.043	0.233

*Mathematics field includes topics such as integers, fractions, algebra, equations and trigonometry. The geometry field includes topics such as geometric shapes and objects, length, area and volume.

The homogeneity value between the groups calculated with regard to the field of study is Q_B=0.123 as shown in Table 5. The chi-square critical value of 1 degrees of freedom at 95% CI level is 3.841. The Q_B value is smaller than the chi-square critical value, and the p value is not significant (p>.05). Thus, it can be stated that RME teaching does not reveal a significant difference in the field of study between the groups.

Table 6 shows the findings of the research's fourth question "How does the overall effect of RME on attitude differ with regard to implementation period?".

Table 6. Effect Sizes Calculated with regard to Implementation Period

Moderator	Q_B	*p*	*df*	*n*	*ES*	%95 CI for *ES* Lower Limit	%95 CI for *ES* Upper Limit	*SE*
Implementation Period*	1.196	0.550	2					
6-10 periods				4	0.734	0.284	1.185	0.230
11-15 periods				6	0.508	0.058	0.957	0.229
16-20 periods				6	0.446	0.190	0.701	0.130

*One period is approximately 40-45 minutes.

The homogeneity value between the groups calculated with regard to the implementation period is Q_B=1.196 as shown in Table 6. The chi-square critical value of 2 degrees of freedom at 95% CI level is 5.991. The Q_B value is smaller than the chi-square critical value, and the p value is not significant (p>.05). Thus, it can be stated that RME teaching does not reveal a significant difference in the implementation period between the groups. It must be stated that five studies which did not define the implementation period and one study determined with an implementation period of 1-5 hours were excluded from the analysis.

Table 7 shows the findings of the research's fifth question "How does the overall effect of RME on attitude differ with regard to sample size?".

Table 7. Effect Sizes Calculated with regard to Sample Size

Moderator	Q_B	*p*	*df*	*n*	*ES*	%95 CI for *ES* Lower Limit	%95 CI for *ES* Upper Limit	*SE*
Sample Size	15.346	0.000	2					
16-30 participants				14	0.523	0.254	0.792	0.137
31-45 participants				5	0.665	0.385	0.946	0.143
46-60 participants				3	1.207	0.961	1.454	0.126

The homogeneity value between the groups calculated with regard to sample size is Q_B=15.346 as shown in Table 7. The chi-square critical value of 2 degrees of freedom at 95% CI level is 5.991. The Q_B value is greater than the chi-square critical value, and the p value is significant (p<.05). Thus, it can be stated that RME teaching reveal a significant difference in the sample size between the groups. As a result, it can be concluded that RME is more successful in groups with a sample size of 46-60 participants. It must be stated that only one study was determined to have 1-15 participants as the sample size and it was excluded from the analysis.

4 | DISCUSSION & CONCLUSION

In this research, the effects of Realistic Mathematics Education on the mathematics attitudes of students studying in Turkey were investigated through meta-analysis, 23 effect sizes of 22 studies were calculated. There are 20 positive and three negative effect sizes. This result shows that RME has a favourable effect on the experimental group in 20 studies. The overall effect size value is positively signed and was calculated as 0.652 with 0.101 standard error. This value is moderate as stated by Cohen et al. (2007). In this regard, it can be concluded that the RME teaching has a favourable effect of moderate level on the mathematics attitudes of students. This conclusion is in line with the findings of prior research (Fauzan, 2002; Kurt & Doğan, 2019; Turmudi & Maulida, 2019; Üzel & Mert Uyangör, 2006; Zulkardi, 2002) which suggest that RME has a favourable effect on mathematics attitude. The three negative-signed effect sizes obtained as a result of the research show that RME has no significant effect on mathematics attitude. This finding is in line with earlier research (Hough et al., 2017; Korkmaz & Korkmaz, 2017; Zakaria & Syamaun, 2017) which are stated that RME has no significant effect on mathematics attitude.

As moderators of the present research, the level of education, field of study, implementation period, and sample size were specified. The moderator analysis revealed that there was no statistically significant difference in the level of education between the groups. The effect sizes calculated for each group were ES=0.902 for primary school, ES=0.522 for middle school, and ES=0.488 for high school. As a result, the effect sizes calculated for primary and middle schools indicate moderate effect, whereas the effect sizes calculated for high school indicate modest effect (Cohen et al., 2007).

There was no statistically significant difference in the field of study between the groups. The effect sizes calculated for each group were ES=0.676 for mathematics and ES=0.586 for geometry. As a result, the effect sizes calculated for mathematics and geometry indicate moderate effect (Cohen et al., 2007).

There was no statistically significant difference in the implementation period between the groups. The effect sizes calculated for each group were ES=0.734 for 6-10 periods, ES=0.508 for 11-15 periods and ES=0.446 for 16-20 periods. As a result, the effect sizes calculated for 6-10 periods indicate moderate effect, whereas the effect sizes calculated for 11-15 periods and 16-20 periods indicate modest effect (Cohen et al., 2007).

There was a statistically significant difference in the sample size between the groups. The effect sizes calculated for each group were ES=0.523 for 16-30 participants, ES=0.665 for 31-45 participants and ES=1.207 for 46-60 participants. As a result, the effect sizes calculated for 16-30 participants and 31-45 participants indicate moderate effect, whereas the effect sizes calculated for 46-60 participants indicate strong effect (Cohen et al., 2007).

As a result, RME has a favourable moderate effect on mathematics attitudes of the students studying in Turkey. Based on this, RME-based teaching can be performed for the students who have negative attitude towards mathematics. In this research process, there was not found any undergraduate study examining the effects of RME on mathematics attitude. Therefore, the subject can be conducted at the undergraduate level.

In this research, the effect of RME on students' mathematics attitude was examined. In future studies, the effects of RME on mathematics achievement, retention of learning, metacognitive thinking skills, learning motivations, mathematics anxiety, etc. can be examined. The effects of RME on mathematics attitude can be examined with different moderators to be determined.

STATEMENTS OF PUBLICATION ETHICS

In this research, the data were collected from open access and published studies. Scientific ethics and publication ethics norms were followed at every stage of the research.

CONFLICT OF INTEREST

There are no conflicts of interest associated with this research.

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