Al-Jabar: Jurnal Pendidikan Matematika
Volume 13, Number 2, 2022, Pages 383 – 400
http://ejournal.radenintan.ac.id/index.php/al-jabar/index

The implementation effect of realistic mathematics education and contextual teaching and learning approaches on the students' mathematical communication ability: A meta-analysis

Nurmala Setianing Putri[1*], Dadang Juandi[1], Al Jupri[1]
[1] Universitas Pendidikan Indonesia, Indonesia.
✉ nurmalasetianingputri@upi.edu*

Article Information
Submitted August 20, 2022
Revised Oct 08, 2022
Accepted Oct 29, 2022

Keywords
Contextual Teaching and Learning;
Mathematical Communication;
Meta-Analysis;
Realistic Mathematics Education.

Abstract

Over the last ten years, many studies have discussed the effect of implementing the Realistic Mathematics Education (RME) and Contextual Teaching and Learning (CTL) approaches on students' mathematical communication ability. However, these studies show inconsistent results. This study aims to analyze the effect of implementing the RME learning approach, the effect of implementing the CTL approach, and the difference in the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability. This research used a quantitative approach with a meta-analysis method. The search for research articles with publication years from 2012 to 2022 was carried out using several databases, namely DOAJ, ERIC, Google Scholar, IOP Publishing, Garuda Portal, Semantic Scholar, and national journals link. Using the PRISMA protocol, the authors obtained 15 research articles on RME and 14 research articles on CTL that met the inclusion criteria and could be used in this study. The results of this study showed that the implementation of the RME learning approach has a moderate influence ($g = 0{,}820$) on students' mathematical communication ability, and the implementation of the CTL approach has a strong influence ($g = 1{,}017$) on students' mathematical communication ability. There is no significant difference between the effect of the RME learning approach's implementation and the CTL approach's effect on students' mathematical communication ability ($Q\_value = 2{,}329$, $p\_value = 0{,}127$). Therefore, the RME and CTL learning approaches can be used as learning alternatives that aim to enhance students' mathematical communication ability.

INTRODUCTION

The activity of practicing mathematical communication ability is one thing teachers must emphasize in learning mathematics because mathematics is closely related to communication activities. Mathematics is an international language, meaning that through mathematics, all people from various parts of the world can communicate with each other related to a problem in mathematics (Ruseffendi, 2014). Even in learning mathematics, students always carry out communication activities to express mathematical ideas, find solutions to a problem, discuss with teachers or other students, ask questions, or do other purposes (Vale & Barbosa, 2017). Thus, all mathematics learning activities can never be separated from activities that require mathematical communication ability, namely the process of completing mathematical problems, constructing and understanding a concept, and discussing or sharing thoughts.

How to cite	Putri, N. S, Juandi, D., & Jupri, A, (2022). The implementation effect of realistic mathematics education and contextual teaching and learning approaches on the students' mathematical communication ability: A meta-analysis. *Al- Jabar: Jurnal Pendidikan Matematika*, *13*(2), 383 – 400.
e-ISSN	2540-7562.
Published by	Mathematics Education Department, UIN Raden Intan Lampung.

The final hope from practicing and enhancing students' mathematical communication ability is that students become more accustomed to using their mathematical communication ability outside of learning. This will make it easier for students to solve everyday problems because they are trained to understand a problem and develop appropriate resolution strategies.

The importance of practicing and enhancing mathematical communication ability has increased the enthusiasm of researchers to research what kind of learning is appropriate so that students are trained to use their mathematical communication ability. There are many approaches, strategies, or methods of learning that are appropriate for the situation. Still, there are two learning approaches that both can encourage the enhancement of students' mathematical communication ability and use problems in the learning process, namely the Realistic Mathematics Education (RME) learning approach through the realistic problem and the Contextual Teaching and Learning (CTL) approach through the contextual problem. The RME learning approach is a mathematics learning approach that aims to encourage students to be able to find mathematical concepts through the use of realistic problems belonging to students' real experiences (Gravemeijer & Doorman, 1999; Rohaeti et al., 2019) while the CTL approach is a learning approach that encourages students to be able to construct and find meaning from a concept through the use of situations in the real world and the process of linking concepts and previous experiences with the concept being studied (Helmiati, 2012; Johnson, 2002).

In an initial search of RME and CTL research articles from various databases, the authors found a total of 545 RME articles and 520 CTL articles. This shows that researchers are enthusiastic about finding alternative appropriate learning approaches to enhance students' mathematical communication ability.

In various studies on RME, varying results were obtained. Some findings show a significant effect of implementing the RME learning approach on students' mathematical communication ability (Marpaung et al., 2020). There was also a mention that implementing the RME learning approach greatly affects students' mathematical communication ability (Turmudi & Maulida, 2019). On the other hand, a study showed an insignificant effect of the implementation of the RME learning approach on students' mathematical communication ability (Bunga et al., 2016). A study also showed an insignificant effect of implementing the RME learning approach on students' mathematical communication ability in schools with accreditation C (Palinussa, Molle, & Gaspersz, 2021). Thus, some of these studies showed inconsistent results between one RME study and another.

The same is true of the CTL studies. In a study, there were findings that showed a significant effect of the implementation of the CTL approach on students' mathematical communication ability (Fajri et al., 2012). In other studies, information was obtained that there was an insignificant effect of the implementation of the CTL approach on students' mathematical communication ability (Bernard, 2015). Thus, some of these studies showed inconsistent results between one CTL study and another.

Based on the previous explanation, it is known that many studies that discuss the topic of research on the effect of implementing the RME and CTL learning approaches on students' mathematical communication ability have been conducted, and the results are inconsistent. It is also important to do a meta-analysis to accumulate a collection of studies with the same research topic so that conclusions can be drawn from the inconsistency of the studies. Thus, meta-analysis research is important to provide information about how much effect the implementation of the RME learning approach has on students' mathematical communication ability, how much effect the implementation of the CTL approach has on students' mathematical communication ability, and the difference in the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability; and can be used as a reference by teachers in determining which learning approach can encourage the enhancement of the quality of learning in schools, especially in students' mathematical communication ability.

A meta-analysis is a statistical tool combining effect sizes from various articles, which aims to estimate the magnitude of the effect in a population (Field & Gillett, 2010). A meta-analysis is also a quantitative approach used to synthesize, accumulate, and analyze findings based on data obtained from various studies (Shah et al., 2020). Thus, meta-analysis is a statistical method carried out by accumulating, combining, synthesizing, and analyzing the combined effect sizes of studies obtained from the existing findings in a collection of research articles. In addition, meta-analyses that accumulate knowledge from existing research findings serve as the foundation of science (Hunter & Schmidt, 2004). Thus, conducting this meta-analysis as a scientific basis for the various existing studies and obtaining comprehensive conclusions from a collection of studies with varying results is important. In addition, previously several researchers have conducted meta-analysis research that analyzed the effect of implementing the RME learning approach on mathematical abilities in general (Juandi, Kusumah, & Tamur, 2022; Tamur et al., 2021; Tamur, Juandi, & Adem, 2020) and analyzed the effect of implementing the CTL approach to mathematical abilities in general (Tamur et al., 2021; Tamur, Mandur, & Pereira, 2021) so that the scope is very broad, but there is also previous meta-analysis research that analyzed the effect of implementing the CTL approach on one of the mathematical abilities, namely the mathematical understanding ability (Tamur et al., 2020). Therefore, in this research, the researcher will narrow the scope of the research, which is only focused on mathematical communication ability.

Based on the background of the problem that the authors have described, this study aims to analyze the effect of implementing the RME learning approach, the effect of implementing the CTL approach, and the difference in the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability.

METHODS

The research method used in this study is a meta-analysis, namely by accumulating, combining, synthesizing, and analyzing the combined effect sizes of studies obtained from the findings contained in the collection of research articles. The steps in conducting meta-analysis research include problem formulation, determination of inclusion criteria, literature search, study selection, study coding, effect size calculation, data interpretation, and data reporting (Cooper, Hedges, & Valentine, 2009).

To determine which articles can be used in this study, inclusion criteria needed to be used as references by the authors so that the research articles collected have the same research topic and are relevant to the research objectives. The inclusion criteria used by the authors in this meta-analysis include the following:

1. The population in the primary studies is students with elementary, junior high, and senior high school education levels.
2. For the RME studies, the treatment is the RME learning approach, while the comparison is the conventional learning approach. In contrast, for the CTL studies, the treatment is the CTL approach, while the comparison is the conventional learning approach.
3. The RME studies in the primary studies must implement or at least mention one of the principles of the RME learning approach, namely the intertwinement principle.
4. The dependent variable in the primary studies is mathematical communication ability.
5. Research in primary studies is a type of experimental or quasi-experimental research. In contrast, the research design may include one of the following research designs: nonequivalent group pretest-posttest design, nonequivalent group post-test only design, randomized control group pretest-posttest design, or randomized control group post-test only design.
6. Statistical information in the primary studies includes three data groups as follows:
   a. The number of samples, the mean, and the standard deviation of the post-test data in each experimental and control group;
   b. The number of samples from the post-test data in each experimental and control group, and the t-value from the test of the mean difference of the post-test data from the two groups;
   c. The number of samples from the post-test data in each experimental and control group and the p-value from the test of the mean difference of the post-test data from the two groups.
7. The year of published research in the primary studies ranges from 2012 to 2022, and the implementation is carried out in Indonesia.

Furthermore, there are four stages that researchers need to do a literature search and study selection, including the identification, screening, eligibility, and inclusion stages (Juandi & Tamur, 2020). An overview of the stages of literature search and study selection using the PRISMA protocol in this study is presented in Figure 1 below:

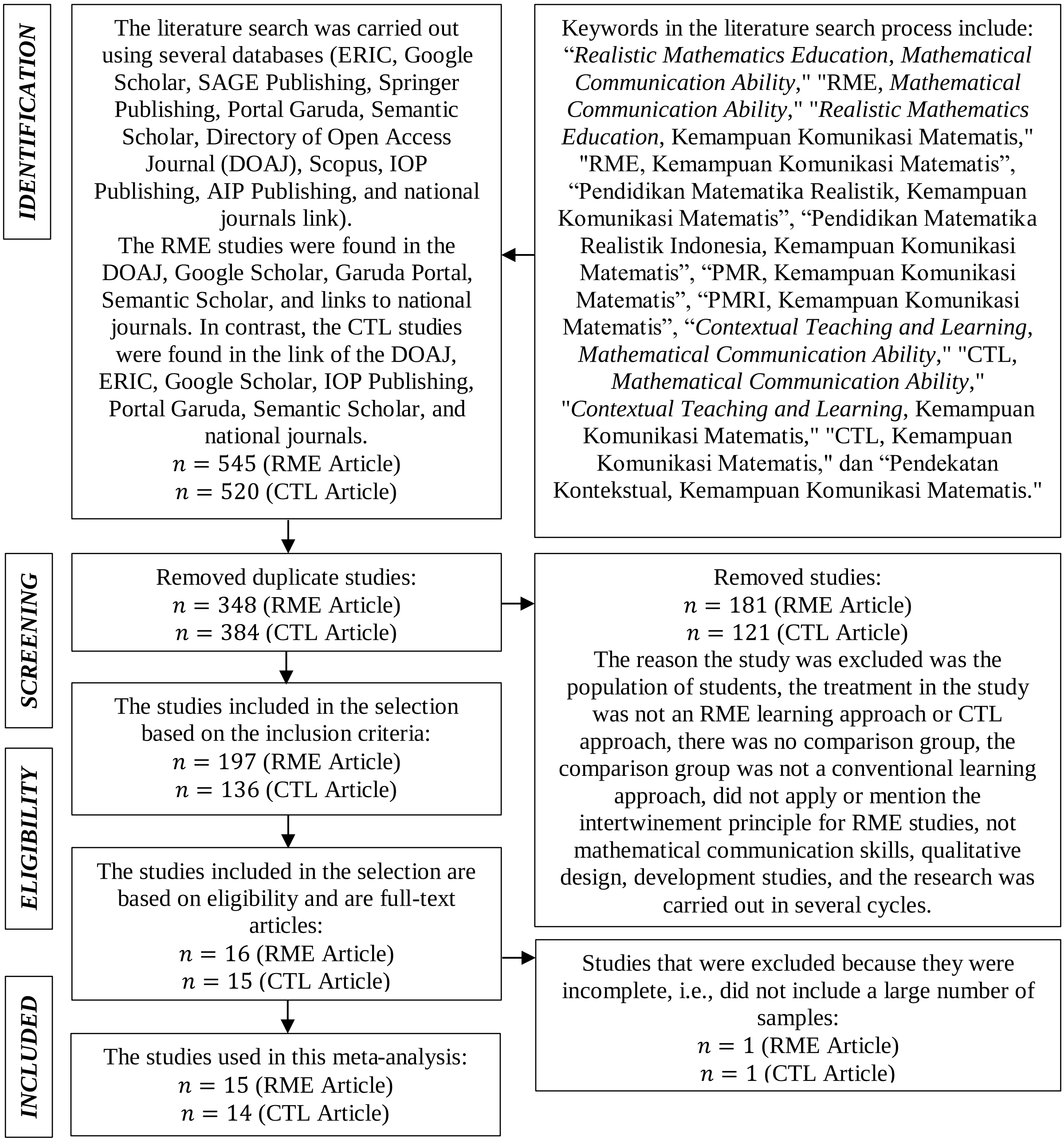

Figure 1. Flowchart Describing PRISMA Stages

Then, the next stage is study coding which includes the data needed in the meta-analysis process, especially the study code, citation, and statistical information. Two other coders besides the authors were involved in the study coding process. At the study coding stage, the research instrument needed is a coding sheet for the coder to write down the coding results and the coding scheme protocol as a guide for the coder in the coding process. Study coding results from the study code, citations, and statistical information on the RME and CTL studies are presented in Table 1 below.

Table 1. Study Coding Results from the Study Code, Citations, and Statistical Information on the RME and CTL Studies

Study Code	Citations	Ne	Me	SDe	Nc	Mc	SDc	t-value	p-value
R1	(Muslimahayati, 2019)	32	74,48	12,26	32	60,21	14,74		
R2	(Heryan, 2018)	30	74,8	7,941	30	70,43	7,328		
R3	(Bunga et al., 2016)	33	65,91	16,32	32	60,94	21		
R4	(Anggraini et al, 2019)	26			28				0,047
R5	(Ariyanti, 2016)	32	13,03	2,75	32	8,625	2,72	6,43	
R6	(Marpaung et al., 2020)	31	76,16	13,43	35	68,34	11,83		
R7	(Palinussa et al., 2021)	42	62,57	19,01	40	54,55	18,1		
R8	(Palinussa et al., 2021)	39	72,68	12,12	32	61,93	14,14		
R9	(Palinussa et al., 2021)	65	74,35	15,53	52	63,23	14,38		
R10	(Suhaedi, 2012)	38	11,026	2,236	37	8,541	2,28		
R11	(Suhaedi, 2012)	31	12,161	1,53	28	9,5	1,972		
R12	(Turmudi & Maulida, 2019)	57	85,06		56	56,96			0
R13	(Kusumaningtias, Syaripudin, & Fitriani, 2021)	17	85,82	10,051	17	71,71	13,665		
R14	(Nababan, 2018)	29	82,41	8,343	29	73,69	6,426	4,461	
R15	(Alam, 2012)	30	18,6333	5,56766	33	16	4,09268		
R16	(Alam, 2012)	41	18,1707	4,27143	38	15,2368	2,54085		
R17	(Alam, 2012)	27	19,1481	3,87997	32	16,9375	4,325		
R18	(Fitria, Surya, & Simbolon, 2021)	25	86,17	7,58	25	78,4	7,77		0
R19	(Nooryanti, Utaminingsih, & Bintoro, 2020)	40	82,35	6,7919	34	77,12	5,8086	3,57	
R20	(Nofrianto, Maryuni, & Amri, 2017)	32	80,23		32	69,37		2,27	
C1	(Nurmala, Hidayat, & Hendriana, 2018)	32	12,47	2,23	30	9,9	1,95		0
C2	(Safitri, Zanthy, & Hendriana, 2018)	30	42,8	10	30	32,07	11,34		0
C3	(Jenab, Islamiyati, & Sariningsih, 2018)	31	9,95	1,8	30	5,46	2,24		0
C4	(Nainggolan, 2015)	42	38,1	4,401	41	33,2	4,613		
C5	(Bernard, 2015)	42	13,32	3,73	40	11,72	4,06		
C6	(Senjayawati, 2015)	30	17,07	2,88	30	12,63	2,75		
C7	(Ruqoyyah, 2018)	20	28,8	9,92	20	18,65	8,45		
C8	(Sugandi & Benard, 2018)	28	9,04	1,79	28	7,59	2,59		0,02
C9	(Jannah, 2014)	23			23			3,347	0,002
C10	(Yonandi & Sumarmo, 2012)	39	77,72	5,53	40	66,55	6,6		
C11	(Yonandi & Sumarmo, 2012)	41	70,02	3,02	44	63,14	7,93		
C12	(Yonandi & Sumarmo, 2012)	38	71,63	5,85	40	66,55	6,6		
C13	(Yonandi & Sumarmo, 2012)	42	70,67	5,07	44	63,14	7,93		
C14	(Manurung, 2017)	77	18,51	2,72	74	16,61	2,55		
C15	(Sugandi, 2015)	42	12,81	2,96	41	10,1	2,99		0
C16	(Rustam & Handayani, 2017)	24	71,18	20,0078	27	60,34	18,01	2,03658	0,044
C17	(Nasution & Nurdalilah, 2017)	35	27,94	10,307	35	22,46	10,359	2,221	0,03

After the study coding stage is complete, the authors need to do a publication bias test first to ensure the number of effect sizes of the RME and CTL studies that will be analyzed in this meta-analysis. In this study, the authors used several methods to conduct a publication bias test, including a funnel plot, trim and fill test, and Rosenthal's Fail-Safe N (FSN) statistics. The authors used the Comprehensive Meta-Analysis (CMA) V3 application to conduct the three types of publication bias tests.

The publication bias test for the RME studies through the funnel plot is presented in Figure 2 below:

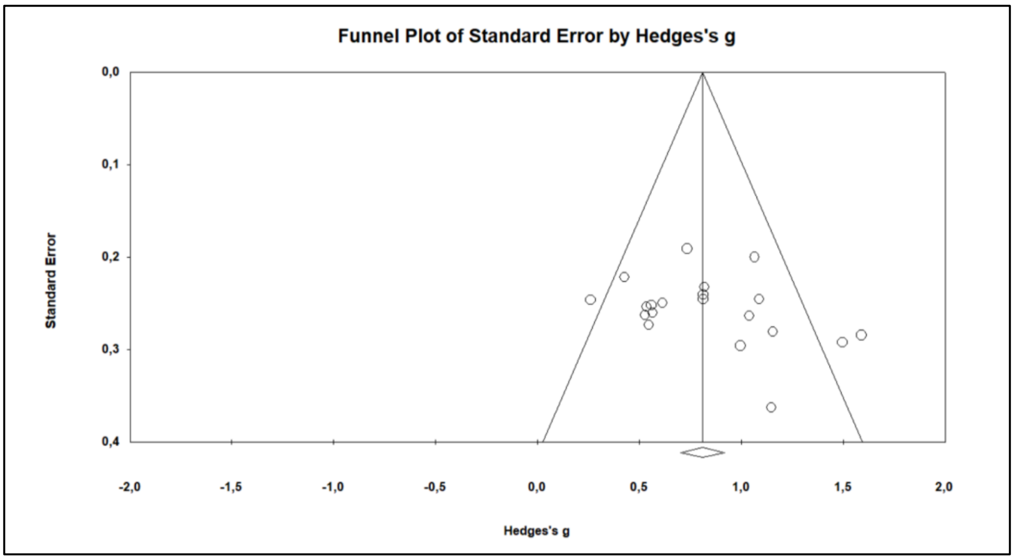

Figure 2. Funnel Plot for RME Studies

Based on Figure 2, information is obtained that the effect size distribution of the 20 RME studies is not completely symmetrical in the center of the funnel plot. Therefore, the authors cannot directly use the 20 RME studies to calculate the effect size. However, the authors need to carry out the next publication bias test, namely the trim and fill test, which aims to determine whether there are RME studies that need to be excluded or need to be added to the analysis process to prevent publication bias.

The publication bias test for the RME studies through the trim and fill viewed from the left and right is presented in Table 2 below.

Table 2. Trim and Fill Test for RME Studies

	Studies Trimmed	Random Effects			Q_value
		Point Estimate	Lower Limit	Upper Limit	
Observed values		0,82011	0,67308	0,96713	33,41502
Adjusted values	0	0,82011	0,67308	0,96713	33,41502

Table 2 shows that no RME study needs to be removed from the analysis process or added to the analysis process, either from the left or right side. To strengthen the publication bias test through the trim and fill, the authors conducted the next publication bias test, namely Rosenthal's FSN statistics.

The publication bias test for the RME studies through Rosenthal's FSN statistics is presented in Table 3 below.

Table 3. Rosenthal's FSN Statistics for RME Studies

Z_value for observed studies	14,56786
P_value for observed studies	0,00000
Alpha	0,05000
Tails	2,00000
Z for Alpha	1,95996
Number of observed studies	20,00000
FSN	1085,00000

By using Rosenthal's FSN statistics formula, namely $\frac{FSN}{5k+10}$, and based on the FSN and $k =$ number of observed studies found in Table 3, authors obtained the following calculation results:

$$\frac{FSN}{5k+10} = \frac{1085}{5(20)+10} = \frac{1085}{100+10} = \frac{1085}{110} = 9.86 > 1$$

Based on these calculations, authors obtained $\frac{FSN}{5k+10} > 1$. Therefore, the interpretation based on Rosenthal's FSN statistic is that there is no possibility of publication bias in this study. Thus, the authors could use 20 RME studies to be included in this meta-analysis.

The publication bias test for CTL studies through funnel plot is presented in Figure 3 below.

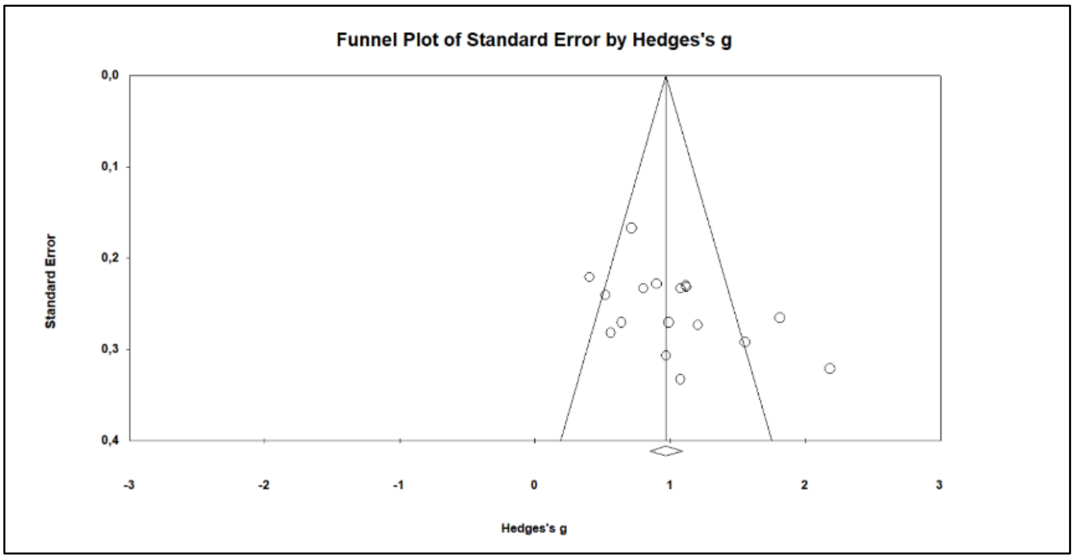

Figure 3. Funnel Plot for CTL studies

Based on Figure 3, information is obtained that the effect size distribution of the 17 CTL studies is not completely symmetrical in the center of the funnel plot. Therefore, the authors cannot directly use the 17 CTL studies to calculate the effect size. However, the authors need to carry out the next publication bias test, namely the trim and fill test, which aims to determine whether there are CTL studies that need to be excluded or need to be added to the analysis process to prevent publication bias.

The publication bias test for the CTL studies through the trim and fill viewed from the left and right is presented in Table 4 below.

Table 4. Trim and Fill Tests for CTL studies

	Studies Trimmed	Random Effects			Q_value
		Point Estimate	Lower Limit	Upper Limit	
Observed values		1,01653	0,81153	1,22152	46,76319
Adjusted values	0	1,01653	0,81153	1,22152	46,76319

Table 4 shows that no CTL study needs to be removed from the analysis process or added to the analysis process, either from the left or right side. To strengthen the publication bias test through the trim and fill, the authors conducted the next publication bias test, namely Rosenthal's FSN statistics.

The publication bias test for the CTL studies through Rosenthal's FSN statistics is presented in Table 5 below.

Table 5. Rosenthal's FSN Statistics for CTL studies

Z_value for observed studies	16,45781
P_value for observed studies	0,00000
Alpha	0,05000
Tails	2,00000
Z for Alpha	1,95996
Number of observed studies	17,00000
FSN	1182,00000

By using Rosenthal's FSN statistics formula, namely $\frac{FSN}{5k+10}$, and based on the FSN and k = number of observed studies found in Table 5, the authors obtained the following calculation results:

$$\frac{FSN}{(5k+10)} = \frac{1182}{5(17)+10} = \frac{1182}{85+10} = \frac{1182}{95} = 12.442$$

Based on these calculations, authors obtained $\frac{FSN}{5k+10} > 1$. Therefore, the interpretation based on Rosenthal's FSN statistics is that there is no possibility of publication bias in this study. Thus, the authors could use 17 CTL studies to be included in this meta-analysis.

Furthermore, after all studies have been freed from publication bias, and the authors have obtained a definite number of the study effect sizes to be analyzed in this study, the authors proceed to the next step, namely calculating the effect sizes of each study and the combined effect size. Because the studies used in this study have diversity in terms of research sample groups, experimenters, sample size, education level, year of study, how the treatment is implemented to research samples, etc., the authors use a random effects model, which assumes that studies used in this study had actual effect sizes that varied at the population level (Borenstein et al., 2009; Juandi & Tamur, 2020; Retnawati et al., 2018).

In calculating the effect size, the authors use an effect size based on the standardized mean difference Hedges' g because the research in the primary studies used a small sample size and sample standard deviation (Fritz, Morris, & Richler, 2012). In determining the interpretation of the effect sizes of the individual RME studies, the effect sizes of the individual CTL studies, the combined effect sizes of the RME studies, and the combined effect sizes of the CTL studies, the authors used the interpretation classification developed by Cohen (Cohen, Manion, & Morrison, 2007) and presented in Table 6 below:

Table 6. Cohen Classification of Effect Size Interpretations

Effect Size (ES)	Interpretation of Effect Size
0,00 ≤ ES ≤ 0,20	Weak effect
0,20 < ES ≤ 0,50	Modest effect
0,50 < ES ≤ 1,00	Moderate effect
ES > 1,00	Strong effect

The next step is to use Q_statistics to analyze the effect of the implementation of the RME learning approach compared to the CTL approach on students' mathematical communication ability (Borenstein et al., 2009).

RESULTS AND DISCUSSION

The authors obtained 15 RME research articles and 14 CTL research articles in this study. After going through the study coding process, the number of effect sizes for the RME studies is 20, and the number of effect sizes for the CTL studies is 17. The entire effect size of the study that the authors obtained will analyze in this study.

Furthermore, using the CMA V3 application, the authors carry out the next stage of the meta-analysis research, namely calculating the effect size. Effect sizes for each RME and CTL study are presented in Table 7 below.

Table 7. Effect Sizes of RME and CTL Studies

Study Code	Effect Size	Interpretation of Effect Size	95% Confidence Interval	
			Lower Limit	Upper Limit
R1	1,040	Strong	0,523	1,556
R2	0,565	Moderate	0,055	1,074
R3	0,262	Modest	-0,221	0,744
R4	0,546	Moderate	0,010	1,082
R5	1,591	Strong	1,034	2,148
R6	0,613	Moderate	0,124	1,102
R7	0,428	Modest	-0,006	0,862
R8	0,814	Moderate	0,332	1,295
R9	0,735	Moderate	0,361	1,109
R10	1,089	Strong	0,609	1,570
R11	1,498	Strong	0,926	2,070
R12	1,065	Strong	0,674	1,457
R13	1,149	Strong	0,438	1,859
R14	1,155	Strong	0,606	1,705
R15	0,536	Moderate	0,039	1,033
R16	0,819	Moderate	0,364	1,274
R17	0,528	Moderate	0,014	1,043
R18	0,996	Moderate	0,417	1,576
R19	0,814	Moderate	0,343	1,285
R20	0,561	Moderate	0,067	1,054
C1	1,209	Strong	0,673	1,745
C2	0,991	Moderate	0,461	1,521
C3	2,185	Strong	1,556	2,815
C4	1,077	Strong	0,620	1,534
C5	0,407	Modest	-0,026	0,840
C6	1,556	Strong	0,984	2,128
C7	1,080	Strong	0,428	1,732
C8	0,642	Moderate	0,112	1,172
C9	0,970	Moderate	0,368	1,572
C10	1,815	Strong	1,294	2,335

Study Code	Effect Size	Interpretation of Effect Size	95% Confidence Interval	
			Lower Limit	Upper Limit
C11	1,121	Strong	0,667	1,575
C12	0,805	Moderate	0,348	1,263
C13	1,116	Strong	0,665	1,567
C14	0,717	Moderate	0,389	1,044
C15	0,903	Moderate	0,455	1,350
C16	0,563	Moderate	0,010	1,115
C17	0,524	Moderate	0,053	0,996

Based on Table 7, various interpretations of effect sizes were obtained for the RME and CTL studies that included three types of levels, namely strong, moderate, and modest. Several articles based on interpretations of effect sizes are presented in Figure 4 below.

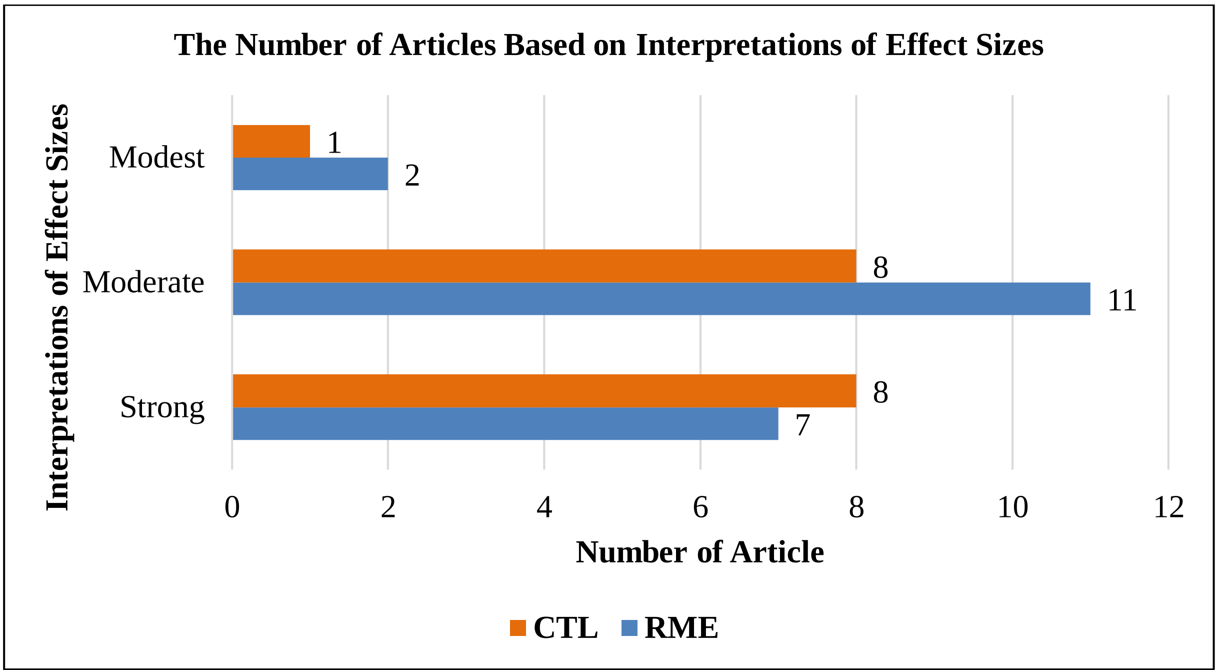

Figure 4. The Number of Articles Based on Interpretations of Effect Sizes

Based on Figure 4, in the RME studies, seven studies obtained findings about a strong effect from the implementation of the RME learning approach on students' mathematical communication ability, 11 studies obtained findings about a moderate effect from the implementation of the RME learning approach on students' mathematical communication ability, and two studies that obtained findings about a modest effect from the implementation of the RME learning approach on students' mathematical communication ability. Furthermore, in the CTL studies, eight studies obtained findings about a strong effect of implementing the CTL approach on students' mathematical communication ability. Eight studies obtained findings about a moderate effect from the implementation of the CTL approach on students' mathematical communication ability, and 1 study obtained findings about a modest effect from the implementation of the CTL approach on students' mathematical communication ability.

In looking for other results related to the effect of implementing the RME and CTL learning approaches on students' mathematical communication ability, the authors reviewed the RME and CTL studies based on 95% confidence intervals. Of the 20 RME studies, there are two studies, namely R3 and R7, whose confidence intervals contain 0, so it is interpreted as an insignificant effect from the implementation of the RME learning approach in both studies on students' mathematical communication ability. Different things were obtained from 18 other studies that the confidence interval did not contain 0 and only included numbers with positive values so that the interpretation results obtained that there was a significant positive effect from the implementation of the RME learning approach in these 18 studies on students' mathematical communication ability. Thus, it can be concluded that not all RME research significantly positively affects students' mathematical communication ability.

Furthermore, of the 17 CTL studies, there is one study, namely C5 whose confidence interval contains 0, so it is interpreted as an insignificant effect of implementing the CTL approach in a study on students' mathematical communication ability. Different things were obtained from 16 other studies that the confidence interval did not contain 0 and only included numbers with positive values so that the interpretation results obtained that there was a significant positive effect from the implementation of the CTL approach in these 16 studies on students' mathematical communication ability. Thus, similar to the RME studies, it can be concluded that not all CTL research significantly positively affects students' mathematical communication ability.

The next analysis the authors did was the effect of the implementation of the RME and CTL learning approaches on students' mathematical communication ability and the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability.

The results of the meta-analysis of the overall RME and CTL studies using the random effects model are presented in Table 8 below.

Table 8. The Results of the Meta-Analysis of the Overall RME and CTL Studies Using the Random Effects Model

Learning Approach in the Experimental Group	n	Effect Size	95% Confidence Interval		Heterogeneity		
			Lower Limit	Upper Limit	q-value	df (Q)	p-value
RME	20	0,820	0,673	0,967	2,329	1	0,127
CTL	17	1,017	0,812	1,222			

The magnitude of the combined effect size for the RME studies is 0.820, which was classified as a moderate effect size level, while the magnitude of the combined effect size for the CTL studies is 1.017, which was classified as a strong effect size level. Thus, information is obtained that the combined effect size of the RME studies is smaller than the combined effect size of the CTL studies.

In addition, the combined effect size of the RME studies gives another interpretation, namely 79% of the total students who receive learning using the conventional approach have a post-test score below the mean of students who receive learning with the RME approach (Coe, 2002). The magnitude of the combined effect size of the CTL studies also gives other interpretation results, namely 84% of the total students who receive learning using the conventional approach have a post-test score that is below the mean of students who receive learning with the CTL approach (Coe, 2002).

Based on Table 8, in the 95% confidence interval column, other interpretations can also be obtained regarding the effect of implementing the RME and CTL learning approaches on students' mathematical communication ability. In the RME and CTL studies, it is known that the 95% confidence interval does not contain 0 and also only contains positive values. Thus, it can be concluded that there is a significant positive effect from the implementation of the RME learning approach on students' mathematical communication ability and a significant positive effect from the implementation of the CTL approach on students' mathematical communication ability.

Furthermore, based on Table 8 on the heterogeneity column, the authors obtained Q_value = 2,329. To find the Q_table, the authors used df = 1 and $\alpha = 0.05$ to obtain the Q_table = 3.84146. Thus, based on this information and the information in Table 8, it is obtained that Q_value < Q_table and p_value > 0.05. Thus, it can be concluded that there is no significant difference in the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability when viewed as a whole. In other words, implementing the RME learning approach has almost the same effect as the CTL approach on students' mathematical communication ability. However, when viewed from the magnitude of the combined effect size descriptively, the implementation of the RME learning approach has a lower effect than the CTL approach on students' mathematical communication ability.

The other findings in this study state that the combined effect size of the RME studies is 0.820, classified as a moderate effect size, and the combined effect size of the CTL studies is 1.017, classified as a strong effect size. These results differ slightly from those of other meta-analyses that showed the combined effect size of the CTL studies was lower than that of the combined effect size of the RME studies. In two other meta-analyses of RME studies, the combined effect size of the RME studies was 0.97, which was classified as moderate effect size (Juandi, Kusumah, & Tamur, 2022). The combined effect size of the RME studies was 1.104, which was classified as a strong effect size (Tamur, Juandi, & Adem, 2020). However, the two meta-analyses analyzed the effect of implementing the RME learning approach on mathematical abilities. In another meta-analysis of the CTL studies, the combined effect size of the CTL studies was 0.88, which is classified as moderate effect size (Tamur et al., 2021). However, this meta-analysis study analyzed the effect of implementing the CTL approach on mathematical ability, as did the other two meta-analyses of RME studies.

Although the combined effect sizes of the RME studies in two other studies of the meta-analysis were greater than the combined effect sizes of the CTL studies in another study of meta-analysis, basically similar findings were obtained that both the implementation of the RME and CTL learning approaches have a positive effect with effect sizes that are at strong and moderate levels. One of the differences in the results of these meta-analysis studies can be caused by using different inclusion criteria in these meta-analysis studies (Borenstein et al., 2009). This study uses the inclusion criteria of the dependent variable in the primary study, which includes only mathematical communication ability. In contrast, the three other meta-analyses use the inclusion criteria of the dependent variable in the primary studies, including mathematical communication ability and mathematical abilities.

There is no significant difference between the effect of the implementation of the RME learning approach and the CTL approach on students' mathematical communication ability, showing that the implementation of the RME learning approach has almost the same effect as the CTL approach on students' mathematical communication ability. This can be seen from the two approaches, which have similarities in their implementation in that both use problems in constructing and finding a concept in mathematics.

However, on the other hand, the two approaches also have their characteristics. Both can support the enhancement of students' mathematical communication abilities. One characteristic that distinguishes the RME learning approach from the CTL approach is the principle of intertwinement. Through the principle of intertwinement, students are encouraged to know the relationship between one concept and another. However, in the process, one material still becomes the main subject (Wijaya, 2012). Using one concept with another requires using mathematical communication ability, for example, when students find other appropriate concepts to help them find solutions to a problem and understand the concepts they are studying.

Another characteristic of RME is using realistic problems in the learning process. Those realistic problems are problems that exist in everyday life or problems that do not exist in everyday life, but students can imagine them (Jupri, 2017). By realistic problems, students have practiced their mathematical communication ability in terms of expressing the situation in pictures, verbally, or in writing; formulating a solution strategy; and using the solution strategy. Thus, the characteristics and foundation of RME can also support the enhancement of students' mathematical communication ability by solving realistic problems and implementing a previous concept to the concept being studied.

The hallmark of the CTL approach is associating a concept with everyday life or student experience so that students feel close to the concepts they are learning, and it can encourage the discovery of the concept's meaning. The core of the CTL approach is the connection that leads students to discover the meaning of a concept (Johnson, 2014). In finding meaning, students cannot be separated from activities to practice their mathematical communication ability. Students can practice communicating situations in everyday life that are in accordance with the mathematical concepts they are studying. Then students can be practiced to share their opinions with other students so that they can add insight into the students themselves. In addition, to find the meaning of any material, students must express their thoughts based on things they have understood in the learning process.

Based on the description of the characteristics, foundation, or core of the RME and CTL learning approaches, it appears that these are some of the factors that support the implementation of the RME and CTL learning approaches to enhance students' mathematical communication ability. Thus, it supports the results of this study that both the RME and CTL learning approaches are equally effective and positively affect the enhancement of students' mathematical communication ability. Therefore, the RME and CTL learning approaches can be used as learning alternatives to enhance students' mathematical communication ability.

This study has several limitations. In addition, this research is only limited to primary studies whose research is carried out in Indonesia. Thus, the authors hope that this research can be further enhanced by analyzing the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability regarding various learning characteristics. The authors also hope that further research will not only involve research articles whose research is carried out in Indonesia.

CONCLUSIONS

This study showed that implementing the RME learning approach moderately influences students' mathematical communication ability. The implementation of the CTL approach strongly influences students' mathematical communication ability. There is no significant difference in the effect of implementing the RME learning approach compared to the CTL approach on students' mathematical communication ability when viewed as a whole. However, when viewed from the size of the effect, descriptively, the implementation of the RME learning approach has a lower effect than the CTL approach on students' mathematical communication ability. Thus, the RME and CTL learning approaches are equally effective and can be used as learning alternatives that aim to enhance students' mathematical communication ability. The authors hope that this research can be enhanced further by comparing the effect of implementing the RME learning approach to the CTL approach on students' mathematical communication ability in terms of various study characteristics. The authors also hope that further research will not only involve research articles whose research is carried out in Indonesia.

ACKNOWLEDGEMENT

This research is supported financially by the Indonesian Endowment Fund of Education (LPDP).

AUTHOR CONTRIBUTIONS STATEMENT

NSP conceived the initial idea, conceived and designed research instruments, role as the main implementer of the research, and role as the main drafter of the manuscript. DJ's role as the supervisor was to provide suggestions regarding the initial idea, provided additional ideas, reviewed research instruments, and supervised the research process. AJ's role as the supervisor was to provide suggestions regarding the initial idea, review research instruments, and supervise the research process. All authors discussed the results and commented on the manuscript.

REFERENCES

Alam, B. I. (2012). Peningkatkan kemampuan pemahaman dan komunikasi matematika siswa sd melalui pendekatan realistic mathematics education (RME). *Seminar Nasional Matematika dan Pendidikan Matematika FMIPA UNY dengan tema "Kontribusi Pendidikan Matematika dan Matematika dalam Membangun Karakter Guru dan Siswa,"* 149–164.

Anggraini, N., Pertiwi, N. I., & Afrilianto, M. (2019). Penerapan pendekatan realistic mathematic education untuk meningkatkan kemampuan komunikasi matematik siswa MTs. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *2*(5), 283–292.

Ariyanti, H. P. (2016). Pengaruh pembelajaran matematika realistik terhadap kemampuan matematis siswa (ditinjau dari kemampuan representasi dan komunikasi). *Buana Matematika: Jurnal Ilmiah Matematika dan Pendidikan Matematika*, *6*(2), 25–30.

Bernard, M. (2015). Meningkatkan kemampuan komunikasi dan penalaran serta disposisi matematik siswa SMK dengan pendekatan kontekstual melalui game adobe flash CS 4.0. *Infinity*, *4*(2), 197–222.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). Introduction to Meta-Analysis. In *John Wiley & Sons, Ltd*.

Bunga, N., Isrok'atun, & Julia. (2016). Pendekatan realistic mathematics education untuk meningkatkan kemampuan koneksi dan komunikasi matematis siswa. *Jurnal Pena Ilmiah*, *1*(1), 441–450.

Coe, R. (2002). It 's the effect size, stupid. what effect size is and why it is important. the british educational research association annual conference.cohen, louis, lawrence manion, dan keith morrison. *Research Methods in Education 6th Edition*. New York: Taylor & Francis e-Library.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education 6th Edition*. New York: Taylor & Francis e-Library.

Cooper, H., Hedges, L., & Valentine, J. (2009). Handbook of research synthesis and meta-analysis 2nd edition. *Russell Sage Foundation*.

Fajri, N., Hajidin, & Ikhsan, M. (2012). Peningkatan kemampuan koneksi dan komunikasi matematis siswa dengan menggunakan pendekatan contextual teaching and learning (CTL). *PARADIKMA: Jurnal Pendidikan Matematika*, *6*(2), 149–161.

Field, A. P., & Gillett, R. (2010). How to do a meta-analysis. *British Journal of Mathematical and Statistical Psychology*, *63*(3), 665–694.

Fitria, H., Surya, E., & Simbolon, N. (2021). The effect of realistic mathematical approaches and learning independence on students' mathematical communication ability SD Negeri Cot Meuraja. *BirLE-Journal (Budapest International Research and Critics in Linguistics and Education)*, *4*(1), 555–569.

Fritz, C. O., Morris, P. E., & Richler, J. J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General*, *141*(1), 2–18.

Gravemeijer, K., & Doorman, M. (1999). Context problems in realistic mathematics education: A calculus course as an example. *Educational Studies in Mathematics*, *39*, 111–129.

Helmiati. (2012). *Model Pembelajaran*. Aswaja Pressindo.

Heryan, U. (2018). Meningkatkan kemampuan komunikasi matematis siswa sma melalui pendekatan pembelajaran matematika realistik berbasis etnomatematika. *Jurnal Pendidikan Matematika Raflesia*, 3(2), 94–106.

Hunter, J. E., & Schmidt, F. L. (2004). *Methods of Meta-Analysis: Correcting Error and Bias in Research Findings 2nd Edition*. Sage Publications, Inc.

Jannah, W. N. (2014). Pembelajaran kontekstual untuk meningkatkan kemampuan pemecahan masalah (aspek metakognitif) dan kemampuan komunikasi matematik siswa sekolah dasar. *Jurnal Penelitian Pendidikan*, *14*(1), 100–108.

Jenab, S., Islamiyati, M., & Sariningsih, R. (2018). Meningkatkan kemampuan komunikasi matematis siswa SMP untuk mengetahui pengaruh pendekatan kontekstual. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *1*(5), 941–948.

Johnson, E. B. (2002). *Contextual Teaching and Learning What It is and Why It's Here to Stay*. Corwin Press, Inc.

Johnson, E. B. (2014). *Contextual Teaching & Learning: Menjadikan Kegiatan Belajar-Mengajar Mengasyikkan dan Bermakna* (I. Setiawan (ed.)). Penerbit Kaifa.

Juandi, D., Kusumah, Y. S., & Tamur, M. (2022). A meta-analysis of the last two decades of realistic mathematics education approaches. *International Journal of Instruction*, *15*(1), 381–400.

Juandi, D., & Tamur, M. (2020). *Pengantar analisis meta*. UPI Press.

Jupri, A. (2017). Pendidikan matematika realistik: Sejarah, teori, dan implementasinya. In U. S. Saud, W. Sopandi, & H. Handayani (Ed.), *Bunga rampai kajian pendidikan dasar: Umum, matematika, bahasa, sosial, dan sains* (page. 85–95). UPI Press.

Kusumaningtias, A., Syaripudin, T., & Fitriani, A. D. (2021). Perbedaan kemampuan komunikasi matematis siswa SD yang menggunakan pendekatan RME dan pendekatan konvensional. *Jurnal Pendidikan Guru Sekolah Dasar*, *6*(2), 25–34.

Manurung, S. L. (2017). Peningkatan kemampuan komunikasi matematis siswa SMP Negeri 14 Medan dengan pendekatan CTL. *Semnastika UNIMED*, *7*(2).

Marpaung, M., Minarni, A., & Panjaitan, T. (2020). The effect of mathematics realistic education aided by mathematics software towards solving mathematical communication problems of Junior High School Students. *BirLE-Journal (Budapest International Research and Critics in Linguistics and Education)*, *3*(3), 1445–1455.

Muslimahayati. (2019). Kemampuan komunikasi matematis siswa dengan pendekatan pembelajaran matematika realistik bernuansa etnomatematika (PMRE). *Jurnal Pendidikan Matematika RAFA*, *5*(1), 22–40.

Nababan, M. J. (2018). Perbedaan kemampuan komunikasi matematis siswa kelas viii smp antara siswa yang diajar dengan pendekatan matematika realistik dan pembelajaran konvensional. *Jurnal Curere*, *2*(2), 105–112.

Nainggolan, A. C. (2015). Penerapan pembelajaran kontekstual untuk meningkatkan kemampuan komunikasi dan koneksi matematis siswa SMP Pencawan Medan. *Jurnal Suluh Pendidikan FKIP-UHN*, *2*(2), 107–118.

Nasution, H. A., & Nurdalilah. (2017). Implementasi pendekatan contextual teaching and learning (CTL) terhadap pembelajaran matematika. *Jurnal Mathematic Paedagogic*, *2*(1), 16–22.

Nofrianto, A., Maryuni, N., & Amri, M. A. (2017). Komunikasi matematis siswa: pengaruh pendekatan matematika realistik. *Jurnal Gantang*, *2*(2), 113–122.

Nooryanti, S., Utaminingsih, S., & Bintoro, H. S. (2020). Pengaruh pendekatan pendidikan matematika realistik berbasis etnomatematika terhadap komunikasi matematis siswa sekolah dasar. *ANARGYA: Jurnal Ilmiah Pendidikan Matematika*, *3*(1), 30–34.

Nurmala, I., Hidayat, W., & Hendriana, H. (2018). Meningkatkan kemampuan komunikasi matematik siswa sekolah menengah pertama melalui pendekatan contextual teaching and learning. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *1*(1), 21–29.

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: Mathematical reasoning and communication ability in rural contexts. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(2), 522–534.

Retnawati, H., Apino, E., Kartianom, Djidu, H., & Anazifa, R. D. (2018). *Pengantar analisis meta*. Parama Publishing.

Rohaeti, E. E., Hendriana, H., & Sumarmo, U. (2019). *Pembelajaran inovatif matematika bernuansa pendidikan nilai dan karakter*. PT Refika Aditama.

Ruqoyyah, S. (2018). Meningkatkan kemampuan komunikasi matematik siswa MA melalui contextual teaching and learning. *Jurnal Ilmiah P2M STKIP Siliwangi*, *5*(2), 85–99.

Ruseffendi, H. E. T. (2014). Hakikat matematika. In *Perkembangan Pendidikan Matematika*. Universitas Terbuka.

Rustam, A., & Handayani, A. L. (2017). Efectivity of contextual learning towards mathematical communication ability of the 7th Grade of SMPN 2 Kolaka. *Journal of Mathematics Education*, *2*(1), 1–10.

Safitri, J., Zanthy, L. S., & Hendriana, H. (2018). Meningkatkan kemampuan komunikasi matematik siswa smp dengan pendekatan contextual teaching and learning (CTL). *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *1*(4), 575–582.

Senjayawati, E. (2015). Penerapan pendekatan kontekstual untuk meningkatkan kemampuan komunikasi matematik siswa SMK di Kota Cimahi. *Didaktik*, *9*(1), 33–39.

Shah, A., Jones, M. P., & Holtmann, G. J. (2020). Basics of meta-analysis. *Indian Journal of Gastroenterology*, *39*(5), 503–513.

Sugandi, A. I. (2015). Penerapan pendekatan konstektual untuk meningkatkan kemampuan komunikasi dan pemecahan masalah serta disposisi matematis siswa SMA. *Seminar Nasional Matematika dan Pendidikan Matematika UNY 2015*, 453–460.

Sugandi, A. I., & Benard, M. (2018). Penerapan pendekatan kontekstual terhadap kemampuan pemahaman dan komunikasi matematis siswa SMP. *Jurnal Analisa*, *4*(1), 16–23.

Suhaedi, D. (2012). Peningkatan kemampuan komunikasi matematis siswa smp melalui pendekatan pendidikan matematika realistik. *Seminar Nasional Matematika dan Pendidikan Matematika FMIPA UNY dengan tema "Kontribusi Pendidikan Matematika dan Matematika dalam Membangun Karakter Guru dan Siswa,"* 191–202.

Tamur, M., Jehadus, E., Nendi, F., Mandur, K., & Murni, V. (2020). Assessing the effectiveness of the contextual teaching and learning model on students' mathematical understanding ability: A meta-analysis study. *Journal of Physics: Conference Series*, *1657*(1).

Tamur, M., Juandi, D., & Adem, A. M. G. (2020). Realistic mathematics education in indonesia and recommendations for future implementation : A meta-analysis study. *JTAM (Jurnal Teori dan Aplikasi Matematika)*, *4*(1), 17–27.

Tamur, M., Kurnila, V. S., Jehadus, E., Ndiung, S., Pereira, J., & Syaharuddin. (2021). Learning from the past : Meta-analysis of contextual teaching-learning of the past decade. *International Journal of Education & Curriculum Application (IJECA)*, *4*(1), 1–10.

Tamur, M., Kurnila, V. S., Jehadus, E., Nurjaman, A., Mandur, K., & Ndiung, S. (2021). The effect of the realistic mathematics education approach: Meta-analysis of the measured mathematical ability angle. *Advances in Social Science, Education and Humanities Research*, *550*, 40–46.

Tamur, M., Mandur, K., & Pereira, J. (2021). Do combination learning models change the study effect size? a meta-analysis of contextual teaching and learning. *Journal of Educational Experts (JEE)*, *4*(1), 1–9.

Turmudi, & Maulida, A. (2019). Effect of the learning aproach of realistic mathematics education on problem solving and mathematics communications effectivity. *6th International Conference on Community Development (ICCD 2019)*, 677–681.

Vale, I., & Barbosa, A. (2017). The importance of seeing in mathematics communication. *Journal of the European Teacher Education Network*, *12*, 49–63.

Wijaya, A. (2012). *Pendidikan matematika realistik suatu alternatif pendekatan pembelajaran matematika*. Graha Ilmu.

Yonandi, & Sumarmo, U. (2012). Mathematical communication ability and disposition (experiment with grade-11 students using contextual teaching with computer assissted). *Jurnal Pengajaran MIPA*, *17*(2), 142–156.