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Learning from the Past: Meta-Analysis of Contextual Teaching-Learning of the Past Decade

Maximus Tamur[1], Valeria S Kurnila[2], Marzuki[3], Emilianus Jehadus[4], Sabina Ndiung[5], Jerito Pereira[6], Syaharuddin[7]
[1,2,4,5]Universitas Katolik Indonesia Santu Paulus Ruteng, Indonesia
[3]Institut Agama Islam Negeri Langsa, Aceh, Indonesia
[6]Guangxi Normal University, China
[7]Universitas Muhammadiyah Mataram, Indonesia
maximustamur@unikastpaulus.ac.id[1]

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Meta-Analysis;
Students' mathematical abilities;
Effect size.

ABSTRAK

This meta-analysis was conducted to summarize the evidence linking the influence of Contextual Teaching-Learning (CTL) on students' mathematical abilities. The research data was obtained from the ERIC database, sage publishing, Scopus database, semantic scholarships, and google scholarships. The 26 studies that met the inclusion requirements were analyzed to obtain an estimate of effectiveness and examined the extent to which the effect of CTL was moderated by year of study, level of education, sample size, and publication source. The random-effect model is estimated, and data processing uses the Comprehensive Meta-Analysis (CMA) software. The results showed the overall effect size of the study was 0.88 (large effect). The moderator analysis results revealed that the implementation of CTL was moderated by the variables of education level and publication source. On the other hand, the studies' heterogeneity reflects that there are still other moderating variables associated with the effectiveness of CTL. The study's limitations and implications are discussed as the basic idea for the implementation of further research.

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A. INTRODUCTION

The current learning orientation is for students to acquire knowledge and competencies that meet modern society's needs (Bolstad, 2020; Nurjanah, Latif, Yuliardi, & Tamur, 2020). In line with that, mathematical skills are needed to process, communicate, interpret, and connect mathematical information in various contexts so that they can adapt to today's complexities (OECD, 2019; Genc & Erbas, 2019). This implies that mastery of mathematical abilities is an important issue. In line with that, Bochniak (2014) places mathematical ability as an important prerequisite for educational attainment and success in the workplace.

Mathematical abilities can be improved through the use of appropriate learning models (Freeman-Green, O'Brien, Wood, & Hitt, 2015). In this regard, there is speculation that learning that uses contextual problems as situations and stimuli can develop students' mathematical abilities (Surya, Putri, & Mukhtar, 2017; Herawaty & Widada, 2018; Purba & Surya, 2020). One

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learning model that is relevant to this context is contextual teaching and learning (CTL). This speculation has spawned replication in continuous research on the effects of CTL.

The application of CTL is allegedly related to students' mathematical abilities. However, individual research investigating these theoretical assumptions has shown ambiguous results. Several research results report that CTL has a major impact on students' mathematical abilities (e.g., Uslima, Ertikanto, & Rosidin, 2018; Sugandi, 2015; Kistian, Fahreza, & Mulyadi, 2020; Surya et al., 2017). Meanwhile, other research results report that CTL is no better than conventional approaches (e.g., Hadjar, 2014; Setiawan & Harta, 2014; Mamartohiroh, Muhandaz, & Revita, 2020). The problem is that there is a need that teachers and other relevant advisers need information that can be considered for future implementation of CTL. The absence of literature that answers this problem causes teachers or researchers not to make new breakthroughs that are certainly oriented to improving students' mathematical abilities.

To fill this gap, it is necessary to integrate quantitative findings to provide accurate information (Higgins & Katsipataki, 2015). To that end, a meta-analysis study was conducted to integrate and interpret findings on the effectiveness of CTL and analyze the extent to which various moderating variables moderated CTL. Meta-analyzes provide strong and profound conclusions (Siddaway, Wood, & Hedges, 2019; Franzen, 2020; Tamur et al., 2021).

We previously examined CTL's effect on students' mathematical comprehension abilities by analyzing 21 individual studies (Tamur, Jehadus, Nendi, Mandur, & Murni, 2020). This study extends previous research, namely analyzing the effects of CTL on all mathematical abilities. However, this study used a strict protocol to ensure transparency and quality of analysis and was not conducted previously. Thus, this study aimed to summarize the evidence about the effect of CTL by finding the size of the overall effect size and to examine the extent to which the effect of CTL was moderated by year of study, level of education, sample size, and publication source. The relationship between these variables contributes to educators in implementing CTL in the future

B. METHODS

This study uses a meta-analysis method that combines a group of individual studies on the effect of CTL and summarizes the results. Like other meta-analysis methodologies (Glass, 2015; Pigott & Polanin, 2020), this research was conducted by considering three stages, namely determining inclusion criteria, collecting data and coding variables, and implementing statistical analysis.

1. Inclusion Criteria

According to the research objectives, individual studies that are considered worthy of analysis in this study are; (a) in the form of national and international journals; (b) investigating the effect of CTL; (c) publications in the last decade; and (d) present descriptive statistics for the calculation of the effect size (ES).

2. Data collection

This study uses an electronic database as a search location which includes ERIC (Education Resources Information Center), SAGE journal, Scopus database, and Google Scholar. Table 1 presents the data search locations.

Table 1. Location Search Data

No	Nama Basis Data	URL
1	ERIC	https://eric.ed.gov/?journals
2	SAGE Journal	https://journals.sagepub.com/
3	Scopus database	https://www.scopus.com/home.uri
4	Semantic scholar	https://www.semanticscholar.org/
5	Google scholars	https://scholar.google.com/

Taking into account the advice from Pigott & Polanin (2020) regarding a transparent and quality data selection process, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) protocol is used as a selection tool. The PRISMA protocol starts by identifying 341 articles collected from the linked database. Then we screened 341 and found 94 articles that were removed due to duplication. The third stage is eligibility, which is selecting articles based on predetermined inclusion criteria. This stage excluded 281 articles from the analysis because they did not meet the inclusion criteria. Thus 26 individual studies were included in this analysis.

This study uses a coding form as a research instrument. The instrument has been developed to extract information from individual studies into numerical data that includes, author's name, year of research, publication source, level of education, sample size, and descriptive statistics for effect size calculations. To obtain the transcoding process's reliability, two independent researchers were hired, and coded 26 studies. Data entry was carried out through Microsoft Excel 2016 software. Reliability tests used the Cappa Cohen coefficient (κ (7)), which is a strong statistic to test the level of agreement between coders (McHugh, 2012). Cohen's kappa formula is; κ (7) = (Pr (a) -Pr (e)) / (1-Pr (e)). Pr (a) represents actually observable agreement, and Pr (e) represents coincidence agreement. A value of 0.85 or greater is predetermined to be considered high. The level of agreement in the study was 0.89 which means, there was a substantial match among coders. thus, the data in this meta-analysis are reliable.

3. Statistic analysis

The unit of analysis in this study is the effect size (ES), which reflects the magnitude of the influence of CTL application on learning outcomes. ES calculation for each study uses a Comprehensive Meta-Analysis (CMA) and a measurement scale based on the Hedges'g equation. ES interpretation uses classification (Cohen, 1988); that is, less than 0.2 (ignored), between 0.2 and 0.5 (small effect), between 0.5 and 0.8 (moderate effect), between 0.8, and 1.3 (large effect) , and more than 1.3 (excellent effect). The estimation method uses a random-effect model because it does not assume that all studies estimate the same true effect (Pigott, 2012). A heterogeneity test was performed using CMA. The null hypothesis (h0), which states that all research results are the same (homogeneous), is rejected if the p-value is <0.05, which means that the ES between studies or study groups is different (Borenstein, Hedges, Higgins, & Rothstein, 2009). Funnel plots and FSN tests were used to reveal the effect of publication bias.

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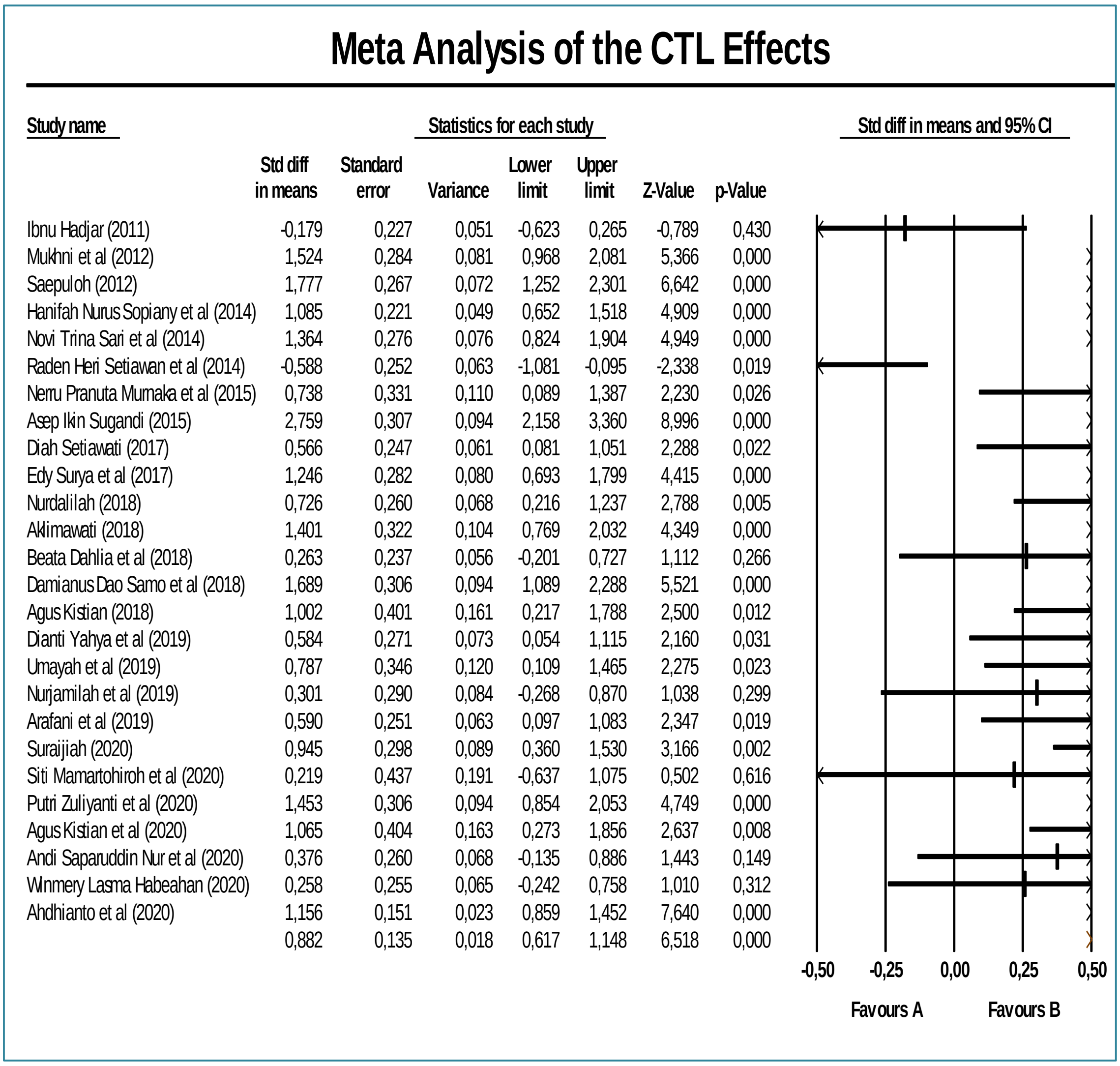
C. RESULT AND DISCUSSION

1. Overall Study ES Analysis

This study's first objective was to reveal the magnitude of the overall effect of using CTL on students' mathematical abilities. The CMA app calculates all effect sizes for each study. Based on these calculations, Figure 1 presents the forest plot effect sizes for each study.



Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Ibnu Hadjar (2011)	-0,179	0,227	0,051	-0,623	0,265	-0,789	0,430
Mukhni et al (2012)	1,524	0,284	0,081	0,968	2,081	5,366	0,000
Saepuloh (2012)	1,777	0,267	0,072	1,252	2,301	6,642	0,000
Hanifah Nurus Sopiany et al (2014)	1,085	0,221	0,049	0,652	1,518	4,909	0,000
Novi Trina Sari et al (2014)	1,364	0,276	0,076	0,824	1,904	4,949	0,000
Raden Heri Setiawan et al (2014)	-0,588	0,252	0,063	-1,081	-0,095	-2,338	0,019
Nerru Pranuta Murnaka et al (2015)	0,738	0,331	0,110	0,089	1,387	2,230	0,026
Asep Ikin Sugandi (2015)	2,759	0,307	0,094	2,158	3,360	8,996	0,000
Diah Setiawati (2017)	0,566	0,247	0,061	0,081	1,051	2,288	0,022
Edy Surya et al (2017)	1,246	0,282	0,080	0,693	1,799	4,415	0,000
Nurdalilah (2018)	0,726	0,260	0,068	0,216	1,237	2,788	0,005
Aklimawati (2018)	1,401	0,322	0,104	0,769	2,032	4,349	0,000
Beata Dahlia et al (2018)	0,263	0,237	0,056	-0,201	0,727	1,112	0,266
Damianus Dao Samo et al (2018)	1,689	0,306	0,094	1,089	2,288	5,521	0,000
Agus Kistian (2018)	1,002	0,401	0,161	0,217	1,788	2,500	0,012
Dianti Yahya et al (2019)	0,584	0,271	0,073	0,054	1,115	2,160	0,031
Umayah et al (2019)	0,787	0,346	0,120	0,109	1,465	2,275	0,023
Nurjamilah et al (2019)	0,301	0,290	0,084	-0,268	0,870	1,038	0,299
Arafani et al (2019)	0,590	0,251	0,063	0,097	1,083	2,347	0,019
Suraijiah (2020)	0,945	0,298	0,089	0,360	1,530	3,166	0,002
Siti Mamartohiroh et al (2020)	0,219	0,437	0,191	-0,637	1,075	0,502	0,616
Putri Zuliyanti et al (2020)	1,453	0,306	0,094	0,854	2,053	4,749	0,000
Agus Kistian et al (2020)	1,065	0,404	0,163	0,273	1,856	2,637	0,008
Andi Saparuddin Nur et al (2020)	0,376	0,260	0,068	-0,135	0,886	1,443	0,149
Winmery Lasma Habeahan (2020)	0,258	0,255	0,065	-0,242	0,758	1,010	0,312
Ahdhianto et al (2020)	1,156	0,151	0,023	0,859	1,452	7,640	0,000
	0,882	0,135	0,018	0,617	1,148	6,518	0,000

Figure 1. The plot of the overall ES forest study

Figure 1 shows ES using CTL giving varying ES distribution. This reflects a moderating effect on the study effect size. Table 2 shows the comparison of the results based on the estimation method.

Table 2. Research results according to the estimation method

Model	N	Hedges's g	Standard error	95% Confidence Interval		Q	P	Decision
				Lower	Upper			
Fixed-effect	26	0.85	0.05	0.74	0.96	159.41	0.00	Reject H0
Random-effect	26	0.88	0.13	0.61	1.14			

Table 2 shows that the p-value <0.05 means heterogeneous ES distribution, which reflects that the estimation model fits the random-effects model. Next, the study funnel plot in Figure 2 was included to check for publication bias. Resistant to publication bias if the ES studies are spread symmetrically (Borenstein, Hedges, Higgins, & Rothstein, 2009). If the 26 ES studies were not completely symmetrical, the FSN test was used. If the value of FSN / (5k + 10)> 1 where k is the number of studies analyzed, this study is resistant to publication bias (Mullen, Muellerleile, & Bryant, 2001).

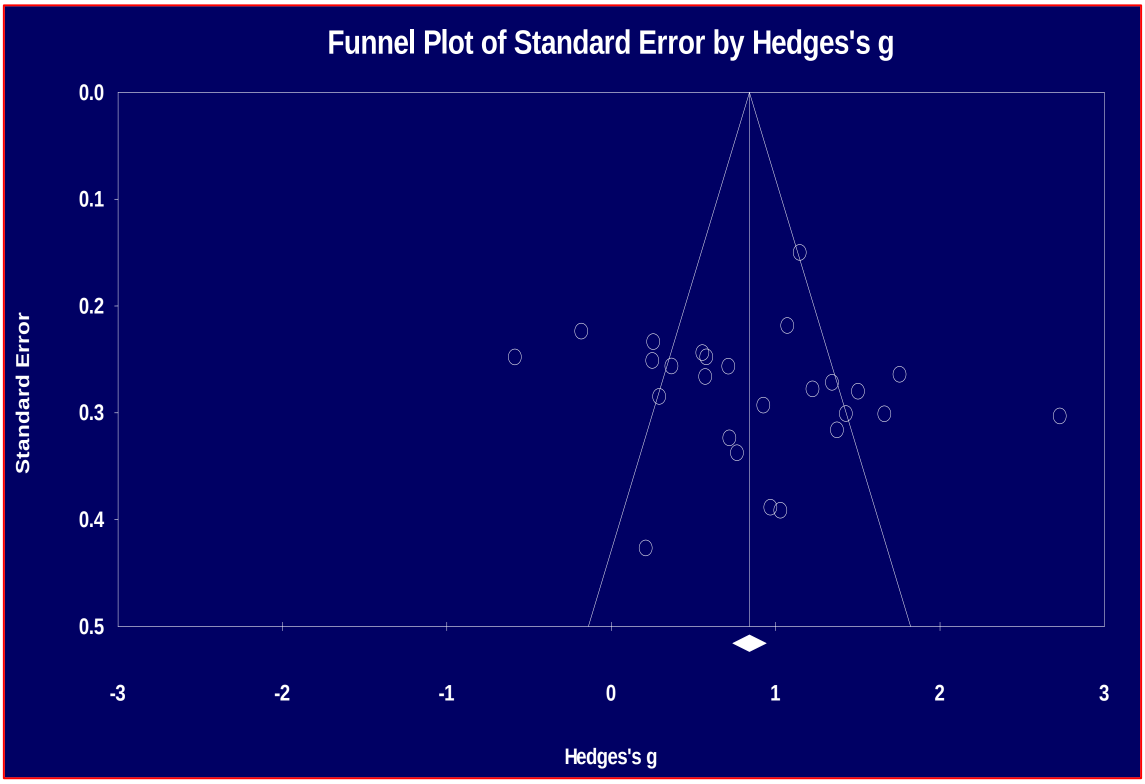


Figure 2. Research funnel plot

When Figure 2 is observed, it appears that the ES studies are not completely spread out across the vertical lines. Therefore, it is necessary to carry out an FSN test to evaluate the extent to which the effects are associated with publication bias in the effect sizes obtained from meta-analyses carried out according to the random-effects model, and the results are presented in Figure 3.

Classic fail-safe N	
Z-value for observed studies	16.06298
P-value for observed studies	0.00000
Alpha	0.05000
Tails	2.00000
Z for alpha	1.95996
Number of observed studies	26.00000
Number of missing studies that would bring p-value to > alpha	1721.00000

Figure 3. Fail-safe N (FSN) test results

The FSN test result is as shown in Figure 3, and the FSN value is 1721. The calculation result of 1721 / (5 * 26 + 10) is 12.19 greater than 1. This estimate indicates that the analyzed study is resistant to publication bias.

2. Moderator analysis results

The results of the analysis show that the ES distribution is heterogeneous so that the mediator variables, namely the year of study, level of education, sample size, and source of publication, are considered to influence the relationship between the dependent and independent variables must be investigated (Arik & Yilmaz, 2020). Table 3 is a summary of the analysis results.

Tabel 3. Results of mediator variable analysis

Mediator Variable	Group	N	Hedge's g	Heterogeneity (Q_b)	df(Q)	P	Decision
Research year	2011 – 2013	3	0.86	2.05	3	0.56	Accept H_0
	2014 – 2016	5	0.95				
	2017 – 2019	11	0.76				
	2020 – 2021	7	0.97				
Educational stage	Primary school (PS)	3	1.12	9.19	2	0.04	Reject H_0
	Junior high school (JHS)	18	0.81				
	Senior high school (SHS)	5	0.79				
Sample Size	30 or less	13	0.90	0.72	1	0.39	Accept H_0
	31 or over	13	0.81				
Source of publication	Journal	18	0.74	9.67	2	0.00	Reject H_0
	Proceedings	6	1.16				
	Thesis	2	0.91				

The results of the studies' overall analysis, as illustrated in Table 2 reveal that the ES from the impact of CTL is estimated to be 0.88 (high effect), which means that CTL has a large impact on students' mathematical abilities. These findings are consistent with the results of research by Tamur, Jehadus, Nendi, Mandur, & Murni (2020), who reported ES 0.86 when they analyzed 21 individual studies of the effect of CTL on mathematical comprehension abilities. However, these findings are slightly different from the results of other studies conducted by Tamur, Juandi, & Adem (2020) concerning the realistic effects of realistic mathematics education (RME) on students' mathematical abilities (ES = 1.14). Although these two models differ from the content of the naming, in terms of implementation and learning components, they are almost the same. The ES of these two models should be almost the same. This difference becomes the basic idea for further research.

The moderator analysis results in Table 3 show that CTL is moderated by differences in education levels and publication sources. The three study groups were different based on the ES education level (P-value = 0.04 <0.05). This indicates that the implementation of CTL must take into account different levels of education. From the distribution of ES, CTL is more effectively applied at the basic education level. This is probably because students at the basic education level need more context to connect the mathematical concepts to be studied (Selvianiresa & Prabawanto, 2020; Kartini, Shidiq, & Nasrudin, 2021; Ahdhianto, Marsigit, Haryanto, & Santi, 2019).

When Table 3 was examined, it was revealed that the effectiveness of CTL was also moderated by differences in publication sources (P-value = 0.00 <0.05). In theory, investigations of differences in published sources as moderating variables are carried out to track the editors' tendency to publish articles (Cooper, 2017). Based on the ES distribution from the three publication sources, it can be seen that the ES journal is higher than the ES proceeding and thesis. These findings reflect that this study is free from research bias.

Table 3 shows that there was no difference in ES between groups (P-value = 0.56> 0.05). This indicates that CTL is not associated with the Hawthorne effect. In theory, the Hawthorne effect exists when high yields are obtained as a result of new treatments (Bayraktar, 2001; Juandi et al., 2021). These results are consistent with previous studies' results that the Hawthorne effect is not related to the effectiveness of the learning model (Susanti, Juandi, & Tamur, 2020; Paloloang, Juandi, Tamur, Paloloang, & Adem, 2020). However, other findings explain that a learning model's effectiveness is related to the Hawthorne effect (Tamur & Juandi, 2020; Tamur, Juandi, & Kusumah, 2020; Yunita, Juandi, Tamur, Adem, & Pereira, 2020).

Furthermore, based on the sample size, it was found that the ES of the 2 study groups was not different (P-value = 0.39> 0.05). This means that there is no specific recommendation regarding CTL implementation if it is connected with many students. This finding is surprising because it differs from our assumption supported by previous studies' results (e.g., Yunita et al., 2020; Tamur et al., 2020) that CTL is more effective when regulated in small groups.

The moderator analysis results revealed that the implementation of CTL was moderated by variables of education level and publication source. On the other hand, the heterogeneity of studies suggests a variation in results between studies, reflecting the large variance between studies. This means that there are other moderating variables related to the effectiveness of CTL. This limitation becomes a new gap as a basic idea for future research implementation.

D. CONCLUSION AND SUGGESTIONS

This study was conducted to summarize the evidence on the magnitude of the influence of CTL on students' mathematical abilities and to examine whether this relationship was moderated by year of study, level of education, sample size, and publication source. The results showed that CTL had a great impact on students' mathematical abilities. However, these findings were only supported by individual studies that were eligible for analysis. There are still many other individual studies that are weak in terms of descriptive statistics for the calculation of ES. This study only analyzes four mediator variables. Further studies are needed to verify these findings by involving more individual studies and including more mediators such as duration of treatment, comparison of effectiveness between countries, a combination of CTL used, and learning resources.

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