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META-ANALYSIS: THE INFLUENCE OF *CONTEXTUAL TEACHING AND LEARNING* APPROACHES ON MATHEMATICAL PROBLEM-SOLVING ABILITIES

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ABSTRACT

Students' ability to solve mathematical problems remains a crucial issue in Indonesian education, often caused by a lack of contextual interaction and teacher-centered learning. This study aims to analyze the impact of the Contextual Teaching and Learning (CTL) approach on students' mathematical problem-solving abilities through a meta-analysis method. A total of 23 primary studies that met the inclusion criteria were analyzed using Comprehensive Meta-Analysis software version 4.0 with a random-effects model. The results show that the CTL approach has a strong and significant effect on students' mathematical problem-solving skills, with an overall effect size (Hedges' g) of 0.819. Moderator analysis indicates that education level, region, and sample size do not significantly influence mathematical problem-solving ability through the CTL model. These findings affirm that the CTL approach is an effective instructional strategy for enhancing students' mathematical problem-solving abilities by connecting abstract concepts to real-world contexts. The educational implications of this study suggest that teachers and policymakers should consistently promote the implementation of CTL to foster more meaningful and contextual mathematics learning.

Keywords: contextual teaching and learning, mathematical problem-solving, meta-analysis, instructional effectiveness, mathematics education

ABSTRAK

Kemampuan siswa dalam memecahkan masalah matematika masih menjadi isu krusial dalam pendidikan Indonesia, yang seringkali disebabkan oleh kurangnya interaksi kontekstual dan pembelajaran yang berpusat pada guru. Penelitian ini bertujuan untuk menganalisis dampak pendekatan Pembelajaran dan Pengajaran Kontekstual terhadap kemampuan pemecahan masalah matematika siswa melalui metode meta-analisis. Sebanyak 23 studi primer yang memenuhi kriteria inklusi dianalisis menggunakan perangkat lunak Meta-Analisis Komprehensif versi 4.0 dengan model efek acak. Hasil penelitian menunjukkan bahwa pendekatan CTL memiliki pengaruh yang kuat dan signifikan terhadap kemampuan pemecahan masalah matematika siswa, dengan ukuran efek keseluruhan (Hedges' g) sebesar 0,819. Analisis moderator menunjukkan bahwa tingkat pendidikan, wilayah, dan ukuran sampel tidak berpengaruh signifikan terhadap kemampuan pemecahan masalah matematika melalui model CTL. Temuan ini menegaskan bahwa pendekatan CTL merupakan strategi pembelajaran yang efektif untuk meningkatkan kemampuan pemecahan masalah matematika siswa dengan menghubungkan konsep-konsep abstrak dengan konteks dunia nyata. Implikasi pendidikan dari penelitian ini menunjukkan bahwa guru dan pembuat kebijakan harus secara konsisten mendorong penerapan CTL untuk mendorong pembelajaran matematika yang lebih bermakna dan kontekstual.

Kata kunci: pengajaran dan pembelajaran kontekstual, pemecahan masalah matematika, meta-analisis, efektivitas instruksional, pendidikan matematika

INTRODUCTION

One of the fundamental abilities that students need in order to learn mathematics is mathematical problem-solving (Setyaningrum et al., 2020). Through this ability, Students must do more than just master mathematical concepts and principles but also to apply them

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in situations relevant to everyday life. According to Polya (as cited in Permatasari & Marlina, 2023), problem-solving is the core of mathematics learning activities because it fosters higher-order thinking skills such as analyzing, evaluating, and creating. However, a number of studies have found that Indonesian students continue to have relatively poor mathematical problem-solving skills. With a mathematical literacy score, Indonesia placed 72nd out of 79 nations in the Programme for International Student Assessment (PISA) 2022. which is less than the OECD average of 489 (OECD, 2023). This indicates that most students are still unable to connect mathematical concepts with real-life contexts (August & Ramlah, 2021).

This issue may be caused by a learning process that remains teacher-centered and emphasizes memorizing formulas and procedural exercises. Students tend to be passive in discovering concepts, resulting in limited opportunities to solve issues and exercise critical thought independently (Latifah & Afriansyah, 2021). Therefore, a learning approach is needed that can connect the material to students' real-world situations and offer meaningful educational opportunities. Contextual Teaching and Learning (CTL) is one method that is thought to be appropriate for these features. According to Johnson (2002), CTL is a learning philosophy that enables instructors to connect instructional content to actual situations and encourages pupils to draw connections between their current understanding and its application in their everyday lives. Students are able to do this as a result. actively build their knowledge by asking questions, working together, and considering their learning experiences (Kistian et al., 2020).

The efficacy of the CTL method in math instruction has been the subject of numerous empirical investigations. The study done by Kistian et al. (2020) showed that CTL can enhance students' mathematical problem-solving abilities by engaging them in contextual and meaningful learning experiences. Similar results were also found by Maya & Ruqoyyah (2021) and Harefa et al. (2022), who reported that CTL improves critical thinking skills, mathematical communication, and student learning outcomes. However, not all studies have shown consistent results. Some studies, such as those by Bintang (2020), Risdiana (2023), and Sulystiani (2024), found that the impact of CTL on mathematical problem-solving ability was moderate, and in some contexts, not statistically significant. These differences in findings may be attributed to factors such as educational level, research location, and sample size used in each study (Rahmaniar et al., 2022).

Results from many studies on the same subject are frequently inconsistent or even contradictory, which can lead to subjective conclusions regarding the research questions (Paloloang et al., 2020). Therefore, these differences highlight the need to incorporate quantitative results to produce accurate and useful conclusions for policy formulation (Pugu et al., 2024). Consequently, a meta-analysis study is necessary to combine and analyze results in order to obtain deeper and more convincing conclusions (Putra & Rahayu, 2021).

By objectively computing and combining effect sizes using mathematical formulae, the meta-analysis technique enhances the probability that various readers would get the same conclusion (Irawan et al., 2024). However, no meta-analysis research has yet focused on the effect of the CTL strategy on students' mathematical problem-solving skills, taking into account moderator variables like educational level (elementary, junior high, senior high), region, and sample size. Meanwhile, educators require precise data to ascertain the circumstances in which the application of CTL can yield the most effective outcomes in enhancing students' mathematical problem-solving skills.

Several previous meta-analysis studies have also examined the effectiveness of the CTL approach success in mathematics education. Nur (2024), in her study titled "Meta-Analysis of the Effect of Contextual Teaching and Learning (CTL) Model on Elementary School Students' Mathematics Learning Outcomes," found that CTL had a large and significant impact on pupils' learning results in maths, using a total effect size of d = 1.07. However, the focus of this study was still limited to general mathematics learning outcomes, not specifically on mathematical problem-solving ability.

Meanwhile, Erlina et al. (2021), through their study titled "Meta-Analysis: Enhancing Students' Critical Thinking Skills through the Implementation of Contextual Learning," demonstrated that the use of CTL significantly improves critical thinking abilities of students, based on an analysis of ten studies involving 654 students. Nevertheless, the study focused more on critical thinking skills rather than mathematical problem-solving ability.

This study expands and complements previous research by examining the overall effect of the CTL approach on mathematical problem-solving ability, while also analyzing variations in effect sizes across studies through moderator variables such as educational level, region, and sample size. This study's objective is to ascertain the extent of CTL's influence on mathematical problem-solving skills and to identify differences in its effectiveness based on those moderator factors. The findings are expected to provide an empirical foundation for developing contextual, meaningful, and effective mathematics learning strategies to enhance students' problem-solving abilities.

METHODS

By examining a number of papers that have been published in national and international journals, this research employs a meta-analysis approach. The main studies that are examined concentrate on the CTL approach effects on pupils' capacity for solving mathematical problems. In general, Borenstein et al. (2021) first, define the inclusion criteria for the analysis of the research. Secondly, develop techniques for collecting empirical data, as outlined in the meta-analysis process. Third, describing the statistical methods that will be used and coding the variables to be explained. The execution of this study follows these steps as well.

Additionally, in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, the studies were identified, screened, and chosen in order to ensure that the review process is transparent and rigorous. Figure 1 displays the PRISMA flow diagram, which provides a summary of the selection procedure for the researches that were analyzed.

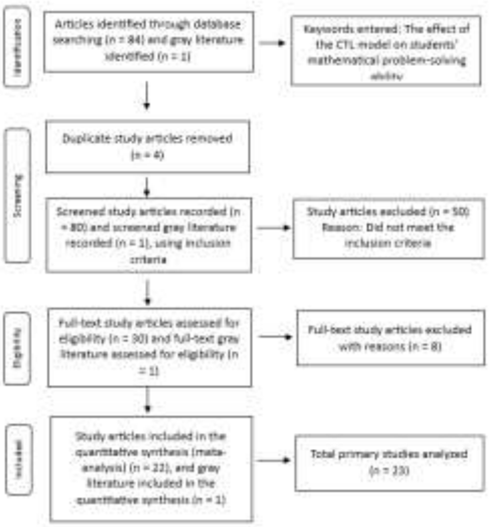

Figure 1. PRISMA Flow Diagram

Inclusion Criteria

Based on the inclusion criteria listed below, all articles found were reviewed and evaluated for appropriateness for inclusion in the meta-analysis during the first search:

1. Articles published between 2019 and 2025.

2. Articles written by Indonesian researchers and published in national or international journals or in proceedings listed in SCOPUS or SINTA.
3. The trials must compare at least one experimental group using the CTL approach with at least one control group using traditional teaching methods or alternative instructional models.
4. In order for the effect size to be calculated or converted, articles must provide enough information.

Data Collection

Empirical data were collected from various databases such as Semantic Scholar, Google Scholar, Publish or Perish, and GARUDA using keywords including *CTL*, *problem-solving ability*, *Mathematical problem-solving ability*, and *problem-solving skill* to identify studies relevant to the research topic. From this search process, 84 articles published between 2019 and 2025 and 1 gray literature source were obtained and reviewed using the PRISMA procedure aligned with the study's objectives. To help find relevant publications, a variable coding sheet was created as a meta-analysis tool. This process involved two coders with expertise in meta-analytic research and systematic reviews, with the goal of ensuring that the information or data extracted is valid and reliable. A coding reliability test, which centered on inter-rater consistency, was done in order to guarantee the accuracy and reliability of the data extraction findings. Since the extraction process only included two raters, the degree of agreement between the two coders was evaluated in this meta-analysis study using the Cohen's Kappa test. The resulting Kappa coefficient was then interpreted based on the standard classification of Kappa values, with calculations performed using SPSS version 26. The classification of Kappa coefficients is presented in Table 1.

Table 1. Classification of Cohen's Kappa

Kappa Value (k)	Interpretation
0 ≤ k < 0,2	Poor
0,2 ≤ k < 0,4	Fair
0,4 ≤ k < 0,6	Moderate
0,6 ≤ k < 0,8	Strong

Kappa Value (k)	Interpretation
0,8 ≤ k ≤ 1	Perfect

Based on the application of the inclusion criteria, a total of 22 articles and 1 gray literature source (undergraduate thesis) were deemed eligible for analysis. These studies were obtained from the Google Scholar, Semantic Scholar, and GARUDA databases. Detailed information about these studies is presented in Table 2.

Table 2. Information on Primary Studies

NO	Moderator Variable	Group	Study
1	Educational Level	Elementary School	5
		Junior High School	11
		Senior High School	7
2	Region	Bali	1
		Java	7
		Sumatra	14
		Sulawesi	1
3	Sampel Size	≤ 30	14
		> 30	9

Statistical Analysis

The effect size is the unit of analysis in a meta-analysis study (Glass, 2015). The effect size is used as an index in this study to show how much the CTL strategy affects students' ability to solve mathematical problems. The statistical analysis procedure refers to Borenstein et al. (2021), which includes: (a) Determining the effect size of each main study, (b) evaluating heterogeneity and selecting the estimating model, and (c) analyzing the possibility of publication bias. and (d) determining the p-value to evaluate the study hypothesis. Furthermore, the 'One study removed' function in the software was used to do a sensitivity analysis. The stability of the meta-analysis findings is evaluated using the thorough meta-analysis (CMA) version 4.0 program. Additionally, an investigation is carried out to determine the reasons for the variance in effect size. after verifying that the model used is a random-effects model, look at the connection between moderator variables (Haidich, 2010).

The software used to assist the data analysis process is Comprehensive Meta Analysis (CMA). Cohen's *d* formula is considered a good estimate of the population parameter, but it tends to produce bias in studies with small sample sizes. Due to variations in sample sizes across studies, this research uses Hedge's *g* formula as the basis for calculating the effect size index. The interpretation of effect size values refers to the criteria proposed by Cohen (Baqi et al., 2023).

Table 3. Categories of Effect Size (ES)

Effect size **(ES)**	**Category**
ES < 0	Ignored
0 < ES < 0.20	Small Effect
0.20 < ES ≤ 0.50	Medium Effect
0,50 < ES ≤ 0.80	Large Effect
ES > 0.80	Very Large Effect

Heterogeneity testing is conducted by examining the Q statistic and p-value. If the result shows $p < 0.05$, the null hypothesis stating that the effect sizes across studies are homogeneous is rejected, and the random-effects model is applied. Conversely, if $p > 0.05$, the null hypothesis is accepted, and the analysis uses a fixed-effect model. Examination of the degree of variation across studies through moderator variable analysis is carried out after confirming that the estimation model used is the random-effects model.

Publication bias assessment is conducted to prevent misrepresentation of research findings. According to Borenstein et al. (2021), published studies tend to be included more frequently in meta-analyses than unpublished ones, which may lead to inflated estimates of effect size. To evaluate the potential for bias, a funnel plot is used, while the Trim and Fill method is applied to detect and correct asymmetry caused by publication bias by trimming studies with extreme effect sizes and adding hypothetical missing studies to balance the distribution. In addition, Rosenthal's Fail-Safe N (FSN) statistic is used to assess the extent to which bias may influence the results (Dewi et al., 2024). A study is considered free from bias if the distribution of effect sizes appears symmetrical around the vertical line in the funnel plot (Borenstein et al., 2021). If not, further testing is conducted using the FSN value. Based on the criteria by Mullen et al. (2001), a study is deemed robust against publication bias if the result of $FSN / (5k + 10) > 1$, where *k* represents the number of studies analyzed (Mullen et al., 2001).

Furthermore, the stability was evaluated by performing a sensitivity analysis utilizing the "One study removed" capability in the Comprehensive Meta-Analysis

(CMA) Version 4.0 software. This analysis, which was performed by sequentially deleting one study and recalculating the overall effect size, aimed to guarantee that none of the meta-analysis results were skewed. One single study unduly influenced the overall results (Borenstein et al., 2021).

RESULTS AND DISCUSSION

A total of 23 primary studies that met the inclusion criteria were used in this analysis. Each study was examined to obtain information regarding research identity, methodological characteristics, and statistical data relevant to effect size calculation. The data extraction process was carried out by two coders with expertise in systematic review and meta-analysis to ensure the accuracy of the results.

The inter-coder consistency test using Cohen's Kappa yielded an average coefficient value of 0.97, demonstrating that the two coders were in complete accord during the data extraction procedure. The data acquired during the extraction was, according to this finding, flawless. The procedure has a lot of legitimacy and reliability. Table 4 provides a detailed presentation of the data obtained from the 23 primary studies.

Table 4. Data extraction results

Code	Citation	Statistical Data						t-value	p-value
		CTL			Conventional				
		n	$\bar{x}$	s	n	$\bar{x}$	s		
A01	manurung dan Hasibuan, 2022	35	79.6	8.56	35	85.34	6.11		
A02	muslihah dan Suryaningrat, 2021	24	34	4.25	25	28	7.5	3.43	
A03	yahya dan yulia, 2019	28	80.3	11.3	29	73.16	13.04	2.21	
A04	Maya dan Ruqoyyah, 2021	20	19.9	4.82	20	15.05	5.29	3	
A05	Mamartohiroh, dkk. 2020	31	41.9	7.27	31	38.92	6.33	4.23	
A06	Zuliyanti dan Pujiastuti, 2020	27	82.7	11.78	27	69.04	6.23		
A07	Bakoban, 2020	32	65.2	12.97	32	55.47	10.51	3.282	
A08	Kistian, dkk. 2020	14	78.8		14	66.58		4.55	
A09	Harefa, ddk. 2022	25	84	7.24	25	80	6.3	2.105	
A10	Buchori, dkk. 2021	28	86.9		29	77.28		6.324	
A11	fitriadi, dkk. 2022	17	8	0.2	26	8.18	0.44		0
A12	Sari, dkk. 2020	21	22.2	2.25	26	17.35	3.75		
A13	Zubaidah, dkk. 2021	33	82.6	9.811	33	77.3	8.476		
A14	Noferina, dkk. 2021	28	38.9	11.69	28	23.96	14.25		
A15	dayani dan hasanuddin, 2020	30	41	20.07	30	32.5	19.29	2.59	0.05
A16	hayati, dkk. 2022	31	88.1	11.42	31	68.92	9.43	7.2	
A17	Ramadoni, dkk. 2023	33	73.3	13.77	33	53.27	12.53		0
A18	Lestari, dkk. 2021	23	79.7	14.28	25	68.28	16.2	2.57	0.013
A19	Anggraini dan Marani, 2022	26	77.8	13.25	26	52.34	13.25		
A20	Dianartasi dan Sthephani, 2021	36	77.3	14.26	35	71.25	14.63	1.73	
A21	Sulystiani, dkk. 2024	22	78.2	11.81	22	72.27	15.409		
A22	Bintang, 2020	38	3.84	2.15	38	2.83	1.81	-2.19	0.032
A23	RISDIANA, 2024	34	29.3	7.92	34	23.79	10.45		

To conduct the analysis, each primary study's impact size was computed. The overall impact size findings from each study are displayed in Table 5.

Table 5. Effect Size Results of Each Study

No	Author	Effect Size	Standar Error	Lower Limit	Upper Limit
1	Manurung dan Hasibuan, 2022	-0.763	0.245	-1.244	-0.283
2	Muslihah dan Suryaningrat A, 2021	0.963	0.298	0.380	1.546
3	Yahya dan Yulia A, 2019	0.576	0.267	0.053	1.099
4	Maya dan Ruqoyyah A, 2021	0.930	0.327	0.289	1.570
5	Mamartohiroh, dkk A. 2020	0.437	0.254	-0.060	0.935
6	Zuliyanti dan Pujiastuti, 2020	1.432	0.302	0.841	2.023
7	Bakoban A, 2020	0.811	0.257	0.307	1.315
8	Harefa, ddk A. 2022	0.586	0.284	0.028	1.144
9	Fitriadi, dkk. 2022	-0.483	0.311	-1.092	0.125
10	Sari, dkk. 2020	1.506	0.328	0.864	2.149
11	Zubaidah, dkk. 2021	0.572	0.248	0.085	1.059
12	Noferina, dkk. 2021	1.130	0.284	0.572	1.687
13	Dayani dan Hasanuddin A, 2020	0.426	0.258	-0.079	0.931
14	Hayati, dkk A. 2022	1.810	0.299	1.225	2.396
15	Ramadoni A, dkk. 2023	1.501	0.276	0.960	2.043
16	Lestari, dkk A. 2021	0.730	0.294	0.155	1.306
17	Anggraini dan Marani, 2022	1.893	0.330	1.245	2.540
18	Dianartasi dan Sthephani A, 2021	0.412	0.237	-0.054	0.877
19	Sulystiani, dkk. 2024	0.423	0.300	-0.164	1.010
20	Bintang A, 2020	0.503	0.231	0.051	0.955
21	Kistian, dkk. 2020	1.670	0.429	0.828	2.511
22	Buchori, dkk. 2021	1.653	0.304	1.057	2.248
23	Risdiana, 2024	0.583	0.245	0.103	1.063

With a 95% confidence level, Table 5 shows that the entire range of impact sizes is between -0.763 and 1.893. It is evident from the classification that two effect sizes are negative (n = 2); four effect sizes are moderate (n = 4); eight effect sizes are (n = 8); and nine effect sizes are very large (n = 9). Two studies (numbers 1 and 11) reported negative effects, indicating that CTL was not more effective than conventional teaching methods. Table 5 presents a comparison of meta-analysis results based on the effect model. As illustrated in Table 5, Table 5 compares the outcomes of meta-analysis results based on the effect model. As illustrated in Table 5, the fixed-effect model predicts that the 95% confidence interval's lower and upper bounds are 0.632 and 0.860, respectively. The studies have an overall effect size of 0.746, which is regarded as a big effect.

The following action is to carry a heterogeneity test and identify the best estimation model. The Q-value from Table 4 is 121.577, with a p-value of 0.000. This demonstrates that the distribution of effect sizes is heterogeneous at a significance level of $p < 0.05$, which means that the actual effect sizes vary between studies. The I-squared value of 81.905 indicates The extent of fluctuation in effect sizes across studies, indicating that real heterogeneity rather than sampling error accounts for about 81% of the observed range in effect sizes. Because the I-squared value is above 75%, this study shows a high degree of heterogeneity (Mullen et al., 2001). Based on these results, the homogeneity hypothesis is rejected, and the random-effects model is adopted. Subsequently, an assessment of potential publication bias is conducted, which is visualized through a funnel plot in Figure 2.

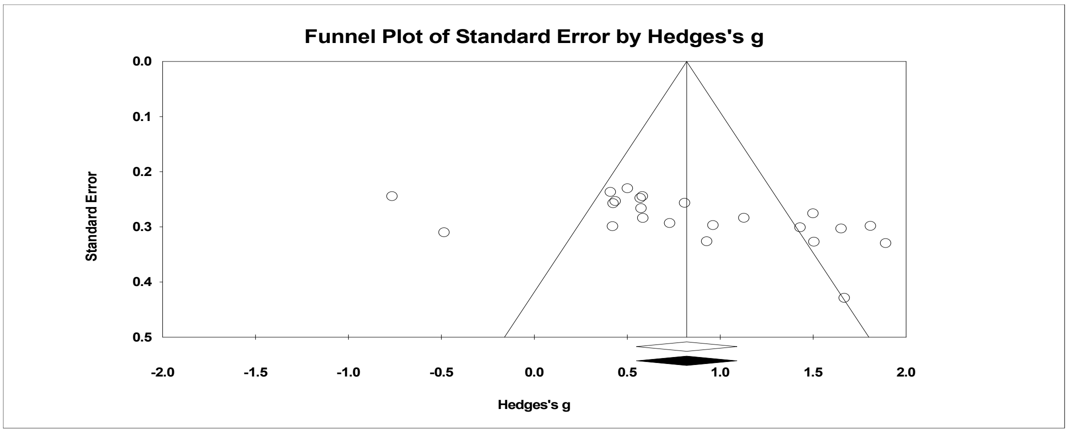

Figure 2. Funnel Plot of the Study

It is evident from Figure 2 that the effect size distribution is not exactly symmetrical with respect to the vertical line. The Trim and Fill test was employed to detect and resolve any publishing bias. Table 6 displays the test's results

Table 6. Trim and Fill Test Results: Mean Effect Size Using Random-Effects Model for CTL's Impact on Mathematical Problem-Solving Ability

	Trimmed studies	Hedges'g	Lower limit	Upper limit	Q value
Observed Value	0	0.81950	0.54918	1.08982	121.57721
Adjusted Value		0.81950	0.054918	1.08982	121.57721

The test's findings revealed that no studies were absent or had to be included. This can be seen from the Hedge's *g* values before and after the Trim and Fill procedure, which showed no difference. Subsequently, an examination was conducted using Rosenthal's Fail-Safe N (FSN) statistic. The calculation performed using the CMA software indicated an *N* value of 1061. When calculated using the formula 1061 / (5 × 23 + 10), the result was 8.48 > 1. This suggests that the studies examined in this study are sufficiently resilient to the impact of publication bias. Consequently, there are no studies that need to be added to the analysis or are missing because of publication bias. Table 7 displays all of the Fail-Safe N test findings.

Table 7. Fail-Safe N Test Results: Data on the Impact of the CTL Approach on Mathematical Problem-Solving Ability

Classic Fail-Safe N	
Z-Value for Observed Studies	13.45501
P-Value for Observed Studies	0.00000
Alpha	0.05000
Z for Alpha	1.95996
Number of Effect Size Data Points	23
Fail-Safe N Value	1061

Furthermore, the "One Study Removed" method in Comprehensive Meta-Analysis (CMA) Version 4.0 was used to do a sensitivity analysis. After each study was eliminated in turn, the data showed that the total effect size stayed constant, suggesting that no single study had a significant impact on the overall conclusions. This consistency implies that the meta-analytic findings are solid and trustworthy.

Table 8. Comparison of Results Based on Estimation Models

No	Estimation model	n	Z	p	Effect Size	Standar Error	95 % CL		Q-value	p-value	I-squared
							Lower Limit	Upper Limit			
1	Fixed effect	23	12.800	0.000	0.746	0.058	0.632	0.860	121.577	0.000	81.905
2	Random effect	23	5.942	0.000	0.819	0.138	0.549	1.090			

The p-value needs to be ascertained in order to test the study hypothesis. Table 8 above presents a comparison of the analysis results based on the estimating model used. The 95% confidence interval for the random-effects model falls between 0.549 and 1.090, suggesting that the mean difference might fall within this range. The combined effect size from all studies is 0.819, which is categorized as a very large effect. Additionally, the Z-test result is 5.942, which is statistically significant at the $p < 0.001$ level. Thus, it can be said that, as compared to traditional methods, the application of the CTL approach significantly improves students' capacity to solve mathematical problems.

Finally, The impact of moderator variables specifically, educational level, area, and sample size on the 23 effect sizes obtained from 23 primary studies was examined in order to analyze the variation among research. The CMA software was used to determine Hedges' g, 95% confidence intervals, Z, and p values, the findings are shown in Table 9.

Table 9. Moderator Analysis Results

NO	Moderator variable	Group	Study	Hedges'g	Test of Null (2-Tail)		Heterogenitas		
					Z	P	Q-value	Df(Q)	P
1	Educational level	ES	5	1.012	4.568	0.000	2.959	2	0.228
		JHS	11	0.98	6.314	0.000			
		SHS	7	0.419	1.362	0.173			
2	Region	Bali	1	1.506	4.597	0.000	6.121	3	0.106
		Java	7	0.815	3.222	0.001			
		Sumatra	14	0.805	4.369	0.000			
		Sulawesi	1	0.423	1.412	0.158			
3	Sample size	≤ 30	14	0.941	5.665	0.000	1.117	1	0.290
		> 30	9	0.641	2.775	0.006			

Educational Level

Based on the analysis in Table 9, studies carried out at the elementary school level (ES) had an impact size of 1.012 (designated as very big), which is almost comparable to the effect size at the junior high school level (JHS) of 0.980 (also categorized as very large). Both, however, are significantly different from the effect size at the senior high school (SHS) level, which was 0.419 (moderate). The average impact sizes across educational levels do not differ significantly, according to the results of the heterogeneity test ($Q = 2.959$ and $p > 0.05$). Consequently, it can be said that the average effect size across the educational level groups does not differ much.

Region

According to Table 9's data, the effect size for research carried out in Bali was 1.506 (classified as very large), while in Java it was 0.815 (also classified as very large). These values are not significantly distinct from the magnitude of the influence in Sumatra, which was 0.805 (also very large). However, all three differ substantially from the effect size reported in Sulawesi, which was 0.423 (classified as moderate). The average effect sizes across regions do not differ significantly, according to the findings of the heterogeneity test ($Q = 6.121$ and $p > 0.05$). Thus, it can be said that students taught using the CTL approach in the regions of Bali, Java, Sumatra, and Sulawesi do not significantly differ in their ability to solve mathematical problems.

Sample Size

Studies with 1–30 participants had an impact size of 0.943 (identified as very big) based on sample size, which was similar to studies with 31 or more participants, which had an effect size of 0.639 (defined as large). The findings of the heterogeneity test show that there is no significant difference in the average effect size between the two research groups

(Q = 1.190 and p > 0.05). Therefore, when comparing the use of the CTL approach with traditional teaching approaches on students' mathematical problem-solving skills, variations in sample size have no effect on the magnitude of the effect size.

The findings of the investigation demonstrate that the use of the CTL strategy has a significant favorable effect on pupils' capacity to solve mathematical problems compared to conventional instruction, with an overall effect size value of 0.819. This effect size suggests that, on average, students who received CTL-based instruction outperformed approximately 81% of students in conventional classrooms who initially had equivalent problem-solving abilities.

Based on Coe’s (2002) interpretation, the experimental group's average student was instructed utilizing the CTL approach ranks around the 79th percentile, which is equivalent to the position of a student at the 50th percentile in the control group. This means that an average-performing student in the CTL classroom performs better than approximately 79% of students in conventional classrooms.

These study results are consistent with earlier meta-analyses by Khoirunnisa et al. (2024), who examined 11 studies and discovered that students' capacity to solve mathematical problems was significantly impacted by the use of the CTL approach. Similar results were also reported in a meta-analysis by Nur (2024), which yielded an overall effect size of 1.07, and by Parhusip & Hardini (2020), who found an average increase of 46.59% in mathematical understanding following the application of CTL. These differences in findings provide a critical foundation for future research to include a larger number of primary studies, expand inclusion criteria, and consider moderator variables such as educational level, region, and sample size to gain a more thorough understanding of how well the CTL approach affects students' mathematics problem-solving ability.

Based on educational level, the meta-analysis results indicate that the effectiveness of the CTL approach on mathematical problem-solving ability varies across different levels of education. The effect size at the elementary school level (ES) was 1.012, at the junior high school level (JHS) was 0.980, and at the senior high school level (SHS) was 0.419. These results show that the impact of CTL is strongest at the elementary school and junior high school levels, both categorized as very large effects, while at the senior high school level it is considered moderate and less significant. This difference in effectiveness can be explained through Piaget’s theory of cognitive development, which states that elementary school and junior high school students are in the concrete operational stage or transitioning toward the formal operational stage, facilitating their comprehension of ideas through real-life contexts and direct experiences. In contrast, senior high school students are already during the official operational phase, which requires abstract thinking, and therefore the contextual approach may sometimes be perceived as less challenging for the complexity of the material.

Moreover, applying the seven CTL elements constructivism, inquiry, questioning, learning community, modeling, reflection, and authentic assessment often falls short at the senior high school (SHS) level. Teachers’ focus on curriculum targets and exam preparation tends to limit the depth of stages such as inquiry, reflection, and authentic assessment. As a result, active student engagement and meaningful learning, which are central to CTL, do not develop optimally. This outcome is in line with the research conducted by Rahmawati et al. (2025), which demonstrated that CTL is more successful when used in elementary and junior high school. Therefore, the implementation of CTL at the senior high school level should be adapted to students’ cognitive characteristics—for example, by strengthening the inquiry and modeling stages through more complex and scientific contexts to remain relevant to their abstract thinking level.

By region, the meta-analysis results on the impact of the CTL approach on mathematical problem-solving ability reveal regional variation. The effect size in Bali was 1.506, in Java 0.815, in Sumatra 0.805, and in Sulawesi 0.423. These findings indicate that the influence of CTL is very large in Bali, Java, and Sumatra, but moderate and less significant in Sulawesi.

This difference can be explained through Vygotsky’s theory of social development, which emphasizes that learning occurs within distinct social and cultural contexts. Regions with strong educational resources, well-prepared teachers, and supportive school policies—such as Bali and Java—demonstrate higher CTL effectiveness. In contrast, areas like Sulawesi face limitations in facilities and suboptimal implementation of CTL components, particularly in the stages of learning community and authentic assessment, resulting in less optimal outcomes. This finding aligns with the study by Siregar et al. (2025), which states that the success of CTL is more influenced by the quality of instructional implementation than by the geographical location of the school. Therefore, CTL can be considered a flexible, contextual, and relevant approach for broadly enhancing students' mathematical problem-solving ability.

The analysis's findings demonstrate that different groups respond differently to the CTL approach in terms of mathematical problem-solving skills based on sample size. An effect size of 0.941 (classified as very large) was found in studies with small sample sizes (≤ 30 participants), whereas an effect size of 0.641 (classified as large) was found in studies with larger samples (> 30 participants). This suggests that CTL remains effective in both groups, although its implementation in smaller classes tends to produce a stronger impact.

This difference occurs because in smaller classes, teachers can more effectively implement CTL elements like questioning, reflection, and inquiry, and learning community, which emphasize direct interaction and meaningful learning. In contrast, in larger classes, time management and the number of students make it more difficult to fully implement stages like reflection and authentic assessment. This finding aligns with the principle of the Central Limit Theorem, as well as the views of Sugiyono (2017, as cited in Sutisna et al., 2023) and Cohen (1988, as cited in Bahri & Zamzam, 2021), which state that sample size affects data stability but does not necessarily determine the strength of the effect. Therefore, CTL remains adaptable for implementation across various class sizes, as long as teachers are able to manage learning in a contextual and interactive manner.

The results of the meta-analysis indicate that the Contextual Teaching and Learning (CTL) approach can be successfully applied to enhance students' mathematical problem-solving skills in a variety of educational settings. To make mathematics more meaningful, educators are urged to create learning activities that incorporate real-world situations and foster active inquiry, questioning, and reflection—all essential components of CTL. These findings emphasize the need of offering professional development programs that enhance teachers' ability to consistently implement CTL concepts in mathematics classrooms for legislators and curriculum designers. Schools should also support smaller group-based learning settings so that educators may more effectively use CTL elements like collaborative learning and genuine assessment.

The quantity and range of the primary studies examined, which were mostly carried out in Indonesia and mostly concentrated on particular educational levels, constrained this meta-analysis. A wider variety of international studies should be included in future study to look at contextual or cultural differences in CTL implementation. More moderator variables, such as students' cognitive styles, instructor experience, or classroom learning environments, may also be examined in future research to offer a greater understanding of the aspects impacting CTL's efficacy in enhancing mathematical problem-solving abilities.

CONCLUSION

According to a meta-analysis of 23 main research, the CTL approach significantly and favorably affects students' mathematical problem-solving ability. CTL has proven to be effective across various educational levels and regions, with relatively consistent levels of effectiveness, and continues to show significant influence in both small and large classroom settings. Overall, these findings affirm that CTL is an adaptive, contextual, and effective instructional strategy for enhancing students' mathematical problem-solving skills.

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