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Meta-Analysis of the Contribution of Cooperative Learning Models to Science Cognitive Outcomes: Evidence Toward SDG 4 in Indonesian Elementary Education

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Abstract: This study evaluated the cognitive learning outcomes of elementary and junior high school students in science subjects after implementing cooperative learning models, using a mean-score meta-analytic approach. A systematic search of Google Scholar, DOAJ, ERIC, Springer, Elsevier, and ResearchGate identified 40 relevant studies, of which 24 met the inclusion criteria and yielded 34 usable effect-size artifacts. Data were analyzed in JASP 0.8.4.0 using a random-effects model (Restricted Maximum Likelihood). For elementary school students, the pooled effect size was 71.86 (95% CI: 66.43–77.29); tested against the minimum completion criterion (KKM) of 75, this value was statistically significantly lower than the criterion ($z = -2.12$, $p < .05$), so H0 was rejected. For junior high school students, the pooled effect size was 76.74 (95% CI: 73.75–79.73), which did not differ significantly from the KKM ($z = 1.41$, $p > .05$), so H0 was retained. Egger's regression test showed no evidence of significant funnel-plot asymmetry at either level (elementary: $z = -0.01$, $p = .989$; junior high: $z = -0.95$, $p = .345$). These findings indicate that, on average, elementary students' science achievement after cooperative learning remained significantly below the minimum completion criterion, while junior high students' achievement was statistically indistinguishable from it. This pattern suggests that implementation fidelity and students' developmental readiness for group-based learning likely moderate the effectiveness of cooperative learning across school levels.

Keywords: Cooperative learning model; Effect size; Meta-analysis; Science education

Introduction

Science education plays a vital role in preparing students to become scientifically literate citizens who are able to make informed decisions and solve real-world problems. At the elementary and junior high school level, students' cognitive development is at a crucial stage, where basic scientific concepts are introduced and developed. The effectiveness of teaching strategies in facilitating students' cognitive learning outcomes—such as understanding, application, analysis, and synthesis—has become a focal point for educational researchers and practitioners (Bybee, 2013).

Traditional teaching methods in science classrooms, particularly teacher-centered approaches such as direct instruction and rote learning, have been criticized for failing to actively engage students and foster higher-order thinking skills. These methods often limit opportunities for students to construct knowledge through collaboration, dialogue, and inquiry-based processes, which are essential for meaningfully understanding scientific concepts (Freeman et al., 2014). Consequently, educators have sought alternative pedagogical models that align with constructivist learning principles.

One such pedagogical innovation is cooperative learning, which emphasizes group-based teaching methods in which students work together to achieve shared academic goals. Various cooperative learning models have been applied in science education, including Jigsaw, Think-Pair-Share (TPS), Teams-Games-Tournaments (TGT), Student Teams–

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Achievement Divisions (STAD), Numbered Heads Together (NHT), and Group Investigation (GI). These models differ in structure and implementation but share the same core principle: collaborative learning. Empirical studies have reported that cooperative learning not only improves academic performance but also motivation, social skills, and attitudes toward science learning (Gillies, 2016).

Recent Indonesian classroom studies illustrate this diversity of models within science education specifically. Jigsaw has been used to improve natural-science learning outcomes at both elementary and junior high levels (Prawiyogi et al., 2024; Tjandrawati, 2017), including when combined with Internet-of-Things-based media to support students' creative thinking (Dewanto et al., 2023). TGT has been applied with various supporting media—word squares, card and snake-and-ladder games, Quizizz, Wordwall, and comic strips—to raise science motivation, literacy, and cognitive outcomes from elementary through junior high school (Afinda et al., 2019; Hermanto & Sukmawati, 2025; Khairi & Sukmawati, 2025; Khoirunnisa & Amaliyah, 2023; Ni'am & Rahayu, 2026; Novritasari et al., 2022; Roza, 2017; Saputri & Sukmawati, 2024). STAD has similarly been paired with interactive or practicum-based media to strengthen science literacy and cognitive learning outcomes (Arisman & Permanasari, 2015; Murdani et al., 2024; Rahayu et al., 2017). NHT has been shown to benefit students of differing academic ability levels (Jampel et al., 2018; Leasa & Corebima, 2017), while Think-Pair-Share and Group Investigation have each demonstrated positive effects on physics and biology learning outcomes (Haryono, 2020; Huang et al., 2023; Limanto et al., 2024). A direct comparison of cooperative approaches in science classrooms further suggests that their relative effectiveness can vary by implementation context (Zurweni et al., 2022). Beyond Indonesia, systematic reviews and meta-analyses of specific cooperative learning models—particularly Jigsaw—report generally positive but implementation-dependent effects on educational outcomes (Berger & Hänze, 2015; Cochon Drouet et al., 2023), a pattern echoed in meta-analytic work on cooperative learning outside science subjects as well (Boke et al., 2025).

Although a growing body of literature confirms the effectiveness of cooperative learning models in science education, findings across studies are not always consistent. Variations in research design, student population, instructional fidelity, and contextual factors contribute to differences in reported results (Dijkstra et al., 2017; Guo & Wang, 2025; Kaihoi et al., 2023). For example, while some studies show statistically significant improvements in cognitive learning outcomes, others report small or no effects. Corroborating this pattern at a larger scale, a recent second-order meta-analysis synthesizing 15 first-order meta-analyses found that cooperative learning has, on average, a moderate effect on learning outcomes, but that this effect differs significantly depending on the specific cooperative learning technique, the academic field, and the experimental design used in the underlying primary studies (Güngör et al., 2026). These mixed results raise the need for systematic synthesis and quantitative analysis.

Meta-analysis offers a rigorous and transparent methodological approach to synthesizing quantitative findings across multiple empirical studies. Unlike narrative reviews, meta-analyses calculate pooled effect sizes to determine the overall impact of an intervention (Gaskell et al., 2022; Paul et al., 2022). Mean-score-based meta-analyses, in particular, allow analysis of measures of central tendency (e.g., mean post-test scores) when standardized mean differences (such as Cohen's d or Hedges' g) are unavailable or inconsistently reported across primary studies (Borenstein et al., 2009). This approach is particularly relevant to classroom-based educational research, although it is acknowledged as a methodological limitation: because raw post-test means do not account for between-group variance in the way a standardized mean difference does, the resulting pooled estimate should be interpreted as a descriptive index of average achievement level rather than a fully standardized measure of intervention effect. This limitation is revisited in the Discussion.

Previous meta-analyses on cooperative learning have largely focused on broad educational outcomes or targeted specific subject areas, such as mathematics or general achievement; for instance, a meta-analysis of 22 Indonesian studies found cooperative learning to have a medium-sized effect on vocational high school students' mathematics learning outcomes (Ridwan et al., 2022). However, few meta-analyses have specifically investigated the impact of cooperative learning on cognitive outcomes in science education for elementary and junior high school students using average score data as the primary metric. In addition, the developmental characteristics of students at the elementary and junior high school levels differ significantly, which may moderate the effectiveness of cooperative learning strategies: elementary school students often require more structured guidance and scaffolding in group activities, while junior high school students may benefit from more autonomous roles and peer-led inquiry.

The novelty of this study is threefold. First, unlike prior meta-analyses that pool outcomes across all educational levels, this study disaggregates findings by elementary and junior high school level, allowing a direct comparison of how cooperative learning performs at two developmentally distinct stages. Second, it benchmarks pooled effect sizes against Indonesia's Minimum Completion Criteria (Kriteria Ketuntasan Minimal, KKM), translating statistical results into a practically meaningful, classroom-relevant standard rather than an abstract effect-size metric alone. Third, it focuses specifically on science learning in the Indonesian context between 2014 and 2024, a combination not yet addressed by existing syntheses. This gap justifies a targeted meta-analytical investigation that considers both school level and the practical achievement threshold used in Indonesian schools, providing evidence that is directly actionable for teachers, curriculum developers, and policymakers seeking to improve science teaching. This focus also speaks directly to Sustainable Development Goal 4 (Quality Education), which calls for inclusive and equitable quality education that ensures effective learning outcomes for all children (United Nations, 2015); evidence on which pedagogical models reliably lift science achievement toward national completion standards is therefore directly relevant to that agenda, and recent Indonesian science-education research has begun framing learning-model evaluation explicitly in these terms (Sampurna et al., 2026).

Therefore, this study aims to conduct a mean-score-based meta-analysis to test the effectiveness of various cooperative learning models in improving elementary and junior high school students' cognitive learning outcomes in science subjects. By synthesizing data from primary studies and comparing outcomes across educational levels, this study seeks to contribute to evidence-based educational practice and inform future instructional decision-making in science education.

Method

The research method used in this study is meta-analysis, a literature-based, quantitative approach that systematically summarizes and synthesizes statistical findings from primary studies addressing comparable research questions (Rifai & Hardjono, 2019). The foundation of meta-analysis relies on artifact data extracted from primary research; before integration, adjustments are made to place these data on a comparable scale. This section describes the data source, the eligibility criteria used to select primary studies, and the procedures used for data analysis.

Data Source

A systematic literature review was conducted to identify empirical research published between 2014 and 2024. Databases and search engines searched included Google Scholar, DOAJ, ERIC, Springer, Elsevier, and ResearchGate. The search strategy used keywords related to cooperative learning models (e.g., Jigsaw, Think-Pair-Share, Teams-Games-Tournaments, Student Teams–Achievement Divisions, Numbered Heads Together, Group Investigation), cognitive learning outcomes, and science education, combined with terms restricting results to the elementary and junior high school levels in the Indonesian context. This process identified 40 potentially relevant documents.

Eligibility Criteria

Study selection followed a PRISMA-style identification, screening, eligibility, and inclusion process, as illustrated in Figure 1. The unit of analysis consisted of published empirical research articles that fulfilled the following inclusion criteria: studies conducted by researchers or students; studies conducted within the Indonesian context; studies published between 2014 and 2024; studies examining students' cognitive learning outcomes in science subjects following the implementation of cooperative learning models; studies involving elementary or junior high school students; studies reporting sufficient statistical information (e.g., mean, median, mode, or standard deviation) for analysis; and studies published in national or international peer-reviewed journals. From the 40 records identified, all studies proceeded to title/abstract screening and full-text eligibility assessment. Seventeen articles were excluded due to insufficient statistical reporting, publication outside the specified time range or geographical context, or misalignment with the targeted educational level and research focus. Consequently, 23 studies satisfied all eligibility criteria and were included in the meta-analysis, contributing 34 effect-size artifacts for synthesis (with some studies providing multiple artifacts, such as separate outcomes across grade levels or measurement occasions).

An essential stage in the meta-analysis involved the coding process, which systematically extracted and organized relevant information using a predefined coding sheet. The coding categories included the researcher's name and publication year, study title, participants' educational level, research topic, type of cooperative learning model or instructional intervention applied, and the dependent variable measured. Data tabulation was conducted by identifying relevant variables, extracting statistical information such as mean scores and standard deviations from experimental and, where available, control groups, and calculating effect sizes based on the reported statistical parameters.

The 23 primary studies retained after the screening process represented science learning research conducted in Indonesian elementary and junior high school settings between 2014 and 2024. The elementary school studies included Dani et al. (2014), Jampel et al. (2018), Nurhayati (2020), Kurniawati (2022), Khoirunnisa et al. (2023), Prawiyogi et al. (2024), Murdani et al. (2024), Astuti et al. (2024), and Lesiela et al. (2024). The junior high school studies included Ikhwati et al. (2014), Purnomo (2016), Darmadi (2015), Doyan et al. (2021), Armimitika (2017), Roza (2017), Sari (2017), Aswirna (2018), Rumbekwan et al. (2018), Rozana (2021), Suendarti et al. (2022), Ismiyanti (2023), Limanto et al. (2024), and Untajana et al. (2024). Collectively, these studies generated the 34 effect-size artifacts analyzed in the subsequent sections, with complete bibliographic information provided in the References section.

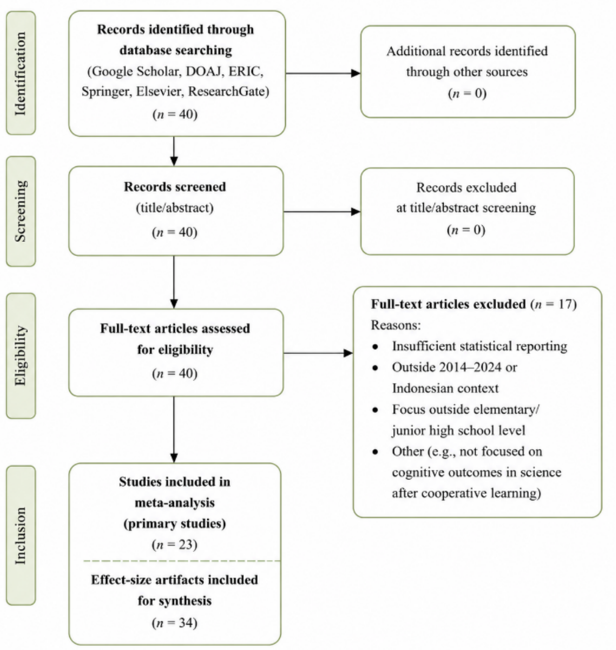

Figure 1. Flow diagram of study identification and selection

Data Analysis

All analyses were performed in JASP (Version 0.8.4.0). Analyses proceeded in three stages: a heterogeneity test to select the pooling model, computation of the effect size and its practical interpretation, and an assessment of publication bias.

Heterogeneity Test

Heterogeneity across the collected effect sizes was assessed using Cochran's Q statistic and its associated p-value, together with the I2 index, where heterogeneity indicates that the effect sizes do not share a single common population value (Higgins et al., 2003). Q was considered to indicate heterogeneity when its p-value fell below .05. I2 quantifies the proportion of total variability attributable to genuine between-study differences rather than sampling error, and was interpreted using conventional thresholds of low (25–50%), moderate (51–75%), and high (>75%) heterogeneity (Borenstein et al., 2009; Higgins et al., 2003). Because Q was significant at both school levels (elementary: $Q = 673.2$, $p < .001$; junior high: $Q = 2530.7$, $p < .001$) and $I2 = 95\%$ at both levels — indicating high heterogeneity — a Random Effects Model was selected for both levels in preference to a fixed-effect model. The between-study variance (τ2) underlying this model was estimated using Restricted Maximum Likelihood (REML), which is generally preferred over method-of-moments estimators such as DerSimonian-Laird because it shows lower bias and mean squared error, particularly with a moderate number of studies (Viechtbauer, 2010).

Effect Size Computation

Unlike meta-analyses that use a standardized mean difference such as Cohen's d or Hedges' g, this study computed effect sizes from raw post-test mean scores, because many of the eligible primary studies did not consistently report the control-group variance needed for a fully standardized effect size. All post-test means were first transformed to a common 0–100 scale so that they would be directly comparable to Indonesia's Minimum Completion Criteria (KKM), which is expressed on the same 0–100 scale; the pooled mean from the random-effects model therefore represents the average achievement level across studies rather than a standardized intervention effect. Pooled estimates were tested against a fixed reference value of 75 (the KKM) using a two-tailed Wald z-test at $\alpha = 0.05$, separately for the elementary and junior high school levels. To aid interpretation of the practical, not purely statistical, meaning of these pooled scores, the following school-based performance bands — adapted from the KKM framework rather than from standardized effect-size conventions such as Cohen's (2013) or Plonsky et al. (2014) benchmarks — were used:

Table 1. Category of Effect Size

Score range	Category
Effect size ≤ 49	Failed
50 < Effect size ≤ 59	Less
60 < Effect size ≤ 69	Sufficient
70 < Effect size ≤ 84	Good
85 < Effect size ≤ 100	Very good

Note: bands adapted from the Indonesian Minimum Completion Criteria (KKM) framework; not equivalent to Cohen's (2013) or Plonsky et al. (2014) standardized effect-size benchmarks.

Publication Bias Assessment

Publication bias was evaluated using two complementary methods for each school level: visual inspection of a funnel plot, in which each study's observed outcome is plotted against its standard error, with symmetry indicating an absence of bias and asymmetry suggesting missing small or low-scoring studies (Egger et al., 1997); and Egger's regression test, in which a statistically significant intercept ($p < .05$) is taken as evidence of funnel-plot asymmetry (Sterne et al., 2011). A rank-correlation test (e.g., Begg and Mazumdar's test) was not computed in the original JASP output for this study and is not reported here; the author team may wish to add it as a further robustness check, since it provides a non-parametric complement to Egger's regression.

Result and Discussion

A total of 34 effect-size artifacts, drawn from 24 included studies, were analyzed using the JASP 0.8.4.0 statistics program. Results are presented separately for elementary school students and junior high school students, each covering the pooled effect size and the corresponding publication-bias analysis.

Cognitive Learning Outcomes of Elementary School Students

Effect Size Analysis

Homogeneity testing of the elementary school effect sizes yielded Q = 673.2, p < .001, indicating that the effect sizes were heterogeneous. Because of this heterogeneity, a Random Effects Model (Restricted ML) was selected. This was further supported by the residual heterogeneity estimate, I2 = 0.95 (on a 0–1 scale), indicating that 95% of the total variance in observed effect sizes reflects genuine between-study heterogeneity rather than sampling error — confirming that a random-effects, rather than fixed-effect, model was appropriate. Results using the random-effects model are shown in Table 2.

Table 2. Average Effect Size

Parameter	Estimate	SE	z	Lower bound	Upper bound
Intercept	71.86	1.48	-2.12	66.43	77.29

Note: Wald test against a test value of 75 (the Minimum Completion Criterion, KKM); α = 0.05.

Table 2 shows a pooled effect size (ES) of 71.86 (95% CI: 66.43–77.29). Because the calculated z value (-2.12) falls outside the critical interval [-1.96, 1.96], it lies in the rejection region: H0 is therefore rejected and Ha is accepted. This indicates that the mean cognitive learning outcome of elementary school students after implementing the cooperative learning model was statistically significantly lower than the Minimum Completion Criterion (KKM) of 75 at α = 0.05. Although the upper bound of the 95% CI (77.29) exceeds 75, the pooled estimate itself, and most of the interval's mass, sits below the threshold, reinforcing that the typical result across studies fell short of the completion standard. Next, using the effect size and its standard error, a forest plot was constructed for interpretation (Figure 2).

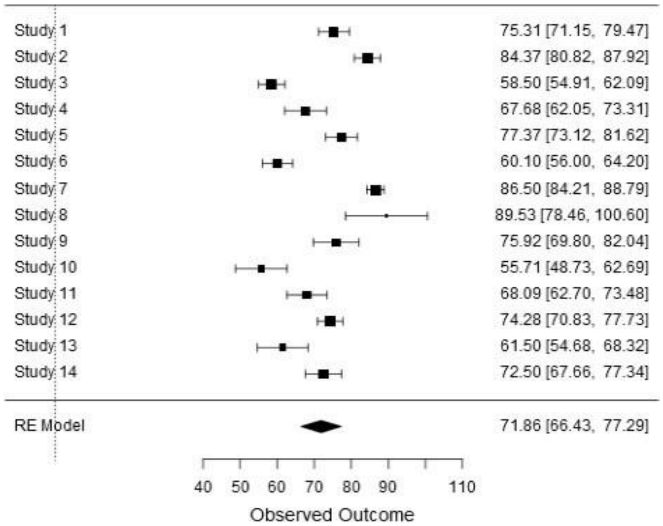

Figure 2. Forest plot of elementary school students' cognitive learning outcomes

Each horizontal line in a forest plot represents the 95% confidence interval for a single study's effect size, while the center marker shows the estimated effect size for that study; larger studies are weighted more heavily, in proportion to the inverse of their variance. The diamond at the bottom of the plot represents the pooled summary effect together with its 95% CI; a narrower diamond indicates a more precise pooled estimate. In this analysis, the diamond falls within the range of many individual study intervals, which supports the credibility of the pooled estimate.

If a study's effect size sits to the right of the pooled estimate, its result exceeded the average across studies; if to the left, its result was below average. Six studies (Study 1, 2, 5, 7, 8, and 9) reported effect sizes above the pooled summary effect, while eight studies (Study 3, 4, 6, 10, 11, 12, 13, and 14) reported effect sizes below it. Consistent with the significance test above, most of the included studies reported average cognitive learning outcomes below the KKM of 75.

Publication Bias Analysis

Publication bias was assessed visually using a funnel plot (Figure 3), which displays each study's observed outcome on the x-axis against its standard error on the y-axis, and statistically using Egger's regression test (Egger et al., 1997).

Most studies clustered near the top of the funnel, where standard errors were small and effect-size estimates were correspondingly precise, indicating close agreement among well-powered studies. A mild asymmetry was observed, with slightly more studies on the right side of the funnel among the more precise estimates, and fewer on the left; however, several lower-performing studies with larger standard errors were also present, suggesting the asymmetry is unlikely to be systematic. Studies at the bottom of the funnel, with larger standard errors, were more widely dispersed but still fell within the expected range, consistent with random sampling variation rather than selective reporting.

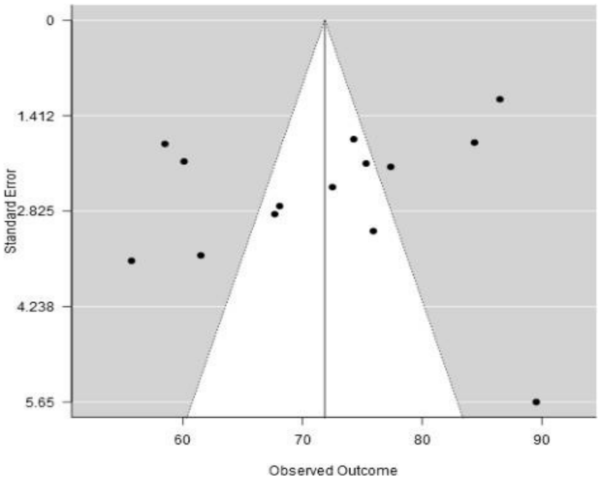

Figure 3. Funnel plot of publication bias for elementary school students' cognitive learning outcomes

The test yielded z = -0.01, p = .989, providing no evidence of statistically significant funnel-plot asymmetry at $\alpha = 0.05$. A non-significant result ($p > .05$) indicates that the mild visual asymmetry is more likely attributable to chance than to systematic publication bias or small-study effects.

Table 3. Regression Test for Funnel Plot Asymmetry ("Egger Test")

Parameter	z	p
sei	-0.01	.989

Note: Egger's regression test for funnel-plot asymmetry.

Cognitive Learning Outcomes of Junior High School Students

Effect Size Analysis

Homogeneity testing of the junior high school effect sizes yielded Q = 2530.7, p < .001, again indicating heterogeneous effect sizes, so a Random Effects Model (Restricted ML) was selected. The residual heterogeneity estimate was I2 = 0.95, similarly indicating that the large majority of variance across studies reflects genuine heterogeneity. Results using the random-effects model are shown in Table 4.

Table 4. Average Effect Size

Parameter	Estimate	SE	z	Lower bound	Upper bound
Intercept	76.74	1.53	1.41	73.75	79.73

Note: Wald test against a test value of 75 (the Minimum Completion Criterion, KKM); $\alpha = 0.05$.

Table 4 shows a pooled effect size of 76.74 (95% CI: 73.75–79.73). Because the calculated z value (1.41) falls inside the critical interval [-1.96, 1.96], it lies in the acceptance region: H0 is retained and Ha is rejected. This indicates that although the pooled mean score exceeds the KKM of 75, there is not enough statistical evidence to conclude that junior high school students' cognitive learning outcomes after cooperative learning differ from the KKM threshold. The 95% CI spans values both below and above 75, reflecting genuine uncertainty about whether the true average performance clears the completion standard. Using the effect size and its standard error, a forest plot was constructed for interpretation (Figure 4).

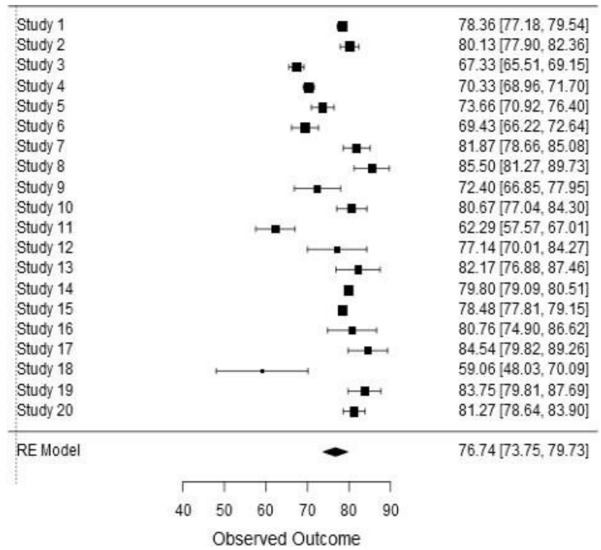

Figure 4. Forest plot of junior high school students' cognitive learning outcomes

As in Figure 2, studies to the right of the pooled estimate exceeded the average, and studies to the left fell below it. Twelve studies (Study 1, 2, 7, 8, 10, 12, 14, 15, 16, 17, 19, and 20) reported effect sizes above the KKM of 75, while eight studies (Study 3, 4, 5, 6, 9, 11, 13, and 18) reported effect sizes below it. Most of the included studies therefore reported average cognitive learning outcomes at or above the KKM, consistent with the pooled estimate of 76.74.

Publication Bias Analysis

Publication bias was again assessed using a funnel plot (Figure 5) and Egger's regression test. Most studies were concentrated near the top of the funnel, indicating lower standard errors and higher-precision effect-size estimates that were closely congruent with the pooled estimate. A mild asymmetry was again observed, with a somewhat greater concentration of high-precision studies on the right side of the funnel and fewer on the left, though studies with lower performance and larger standard errors were also present at the bottom of the funnel, consistent with random sampling variation rather than a systematic pattern.

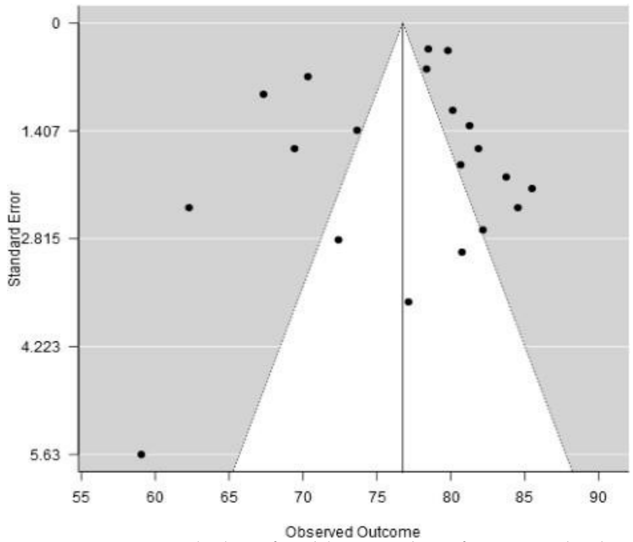

Figure 5. Funnel plot of publication bias for junior high school students' cognitive learning outcomes

Table 5. Regression Test for Funnel Plot Asymmetry ("Egger Test")

Parameter	z	p
sei	-0.95	.345

Note: Egger's regression test for funnel-plot asymmetry.

The test yielded z = -0.95, p = .345, again providing no evidence of statistically significant funnel-plot asymmetry at α = 0.05.

Discussion

Across the two systematic database searches (Google Scholar, DOAJ, ERIC, Springer, Elsevier, and ResearchGate), 40 studies were initially identified. After screening for relevance and the availability of usable statistical data, 24 studies met the inclusion criteria, from which 34 effect-size artifacts were extracted. Because these 34 artifacts used different original scoring scales, all scores were first transformed to a common 0–100 range before pooling.

For elementary school students, the mean effect size (ES) was 71.86 (95% CI: 66.43–77.29), statistically significantly below the Minimum Completion Criterion (KKM) of 75 (z = -2.12, p < .05; H0 rejected, Ha accepted). This indicates that, on average, elementary students' cognitive learning outcomes in science after cooperative learning fell short of the completion standard — a more cautionary finding than the frequently cited benefits of cooperative learning in the literature. According to Slavin (1995), cooperative learning strategies such as Jigsaw and Student Teams-Achievement Divisions (STAD) are associated with meaningful cognitive gains through structured peer interaction, individual accountability, and shared learning goals; Johnson and Johnson (2009) similarly argue that cooperative learning fosters deeper understanding through positive interdependence. The gap between these expectations and the present finding may reflect several contextual and methodological factors. First, the fidelity of implementation matters: inadequate teacher training, insufficient monitoring, or superficial application of cooperative techniques can blunt their potential benefits (Gillies, 2016). This is not merely a theoretical caveat — in an experimental test of the Jigsaw method, Berger et al. (2015) found that novice students' academic performance depended directly on the quality of expert teaching they received within their group, meaning the same cooperative structure can produce very different outcomes depending on how well it is facilitated. Second, student-level variables such as prior knowledge, motivation, and interpersonal competence influence how well cooperative arrangements succeed (Roseth et al., 2008). Because elementary-age students typically require more scaffolding and structured guidance for group work than older students, cooperative learning may need additional support — such as clearer role assignment and closer teacher facilitation — to be effective at this level (Van Ryzin & Roseth, 2021).

For junior high school students, the mean effect size was 76.74 (95% CI: 73.75–79.73). Although this pooled estimate exceeds the KKM of 75, the difference was not statistically significant (z = 1.41, p > .05; H0 retained), so the data do not provide sufficient evidence that junior high students' outcomes reliably exceed the completion standard. This nuanced result contrasts with literature that more uniformly credits cooperative learning — including Jigsaw, Think-Pair-Share, and STAD — with improved content mastery through increased cognitive engagement (Gillies, 2007; Johnson & Johnson, 2009; Roseth et al., 2008; Slavin, 1995). One likely explanation is variability in how consistently cooperative learning was implemented across the included studies: outcomes depend heavily on teacher facilitation, group composition, role clarity, and interaction quality (Gillies & Boyle, 2010). This aligns with a direct comparison of cooperative approaches within Indonesian science classrooms, which found that different cooperative learning models did not produce uniform gains and that their relative effectiveness depended on how each was implemented in context (Zurweni et al., 2022)—consistent with this study having pooled multiple distinct models (Jigsaw, TGT, STAD, NHT, GI) rather than a single, tightly controlled intervention. Another explanation is heterogeneity in junior high students' readiness for collaborative work — some students in some studies may lack the collaborative skills or motivation to engage meaningfully in group tasks, which would help explain why the lower bound of the confidence interval (73.75) sits below the KKM.

Taken together, these findings suggest that cooperative learning, while promising, should not be adopted uncritically at either school level. Educators should treat implementation fidelity, scaffolding appropriate to students' developmental stage, and ongoing formative assessment as prerequisites for realizing the model's benefits, rather than assuming the model itself guarantees improved outcomes. It should also be noted, as a methodological limitation, that this meta-analysis pooled raw mean post-test scores rather than a standardized mean difference (e.g., Cohen's d or Hedges' g); this choice was necessary because many primary studies did not consistently report control-group variance, but it means the pooled estimate reflects an absolute achievement level rather than a fully standardized measure of the cooperative-learning effect relative to a comparison condition. Future research should therefore report control-group statistics more consistently, and should explore moderating variables such as teacher facilitation style, group composition, and student engagement — ideally through mixed-methods designs that combine quantitative pooling with qualitative insight into classroom implementation.

Read against Sustainable Development Goal 4's call for inclusive, equitable quality education with effective learning outcomes for all children (United Nations, 2015), these results are a reminder that adopting a cooperative pedagogy is not, by itself, sufficient to guarantee that outcome: the elementary-level finding in particular shows that a widely-endorsed model can still leave average achievement significantly below a national completion standard when implementation conditions are not adequately supported. Realizing SDG 4 through cooperative learning in Indonesian science classrooms therefore likely depends less on which model is chosen than on investing in the teacher training, facilitation quality, and developmentally appropriate scaffolding that this discussion has identified as recurring gaps (Sampurna et al., 2026).

Conclusion

This meta-analysis found that cooperative learning models produced a pooled cognitive-learning effect size of 71.86 (95% CI: 66.43–77.29) for elementary school students in science subjects, which was statistically significantly below the Minimum Completion Criterion (KKM) of 75 ($z = -2.12$, $p < .05$; H0 rejected, Ha accepted). For junior high school students, the pooled effect size was 76.74 (95% CI: 73.75–79.73); although this estimate exceeded the KKM, the difference was not statistically significant ($z = 1.41$, $p > .05$; H0 retained, Ha rejected). Together, these results indicate that cooperative learning brought elementary students' average science achievement close to — but significantly below — the completion standard, while junior high students' achievement was statistically indistinguishable from it. This pattern points to implementation fidelity and students' developmental readiness for collaborative work as likely moderators of cooperative learning's effectiveness, and suggests that elementary-level implementations in particular may benefit from additional scaffolding and closer teacher facilitation. These findings offer research-based evidence for policymakers, curriculum developers, and teachers seeking to strengthen the practical application of cooperative learning models in Indonesian science classrooms.

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Author Contributions

Conceptualization, A.R. and D.M.F.; methodology, A.R., D.M.F., and A.S.; formal analysis, A.R.; investigation, A.R., A.S., and L.Y.S.; resources, A.R., D.M.F., A.S., and L.Y.S.; writing—original draft preparation, A.R.; writing—review and editing, D.M.F., A.S., and L.Y.S.; visualization, A.R.; supervision, D.M.F.; project administration, A.R.; funding acquisition, A.R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest related to this research.

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