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A Meta-Analysis of the Effectiveness of Cooperative Learning on Students' Learning Outcomes

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ABSTRACT

Purpose This study examines the effectiveness of cooperative learning in improving students' learning outcomes across different educational contexts. Although numerous studies have reported positive impacts of cooperative learning, variations in educational levels, subject areas, and instructional settings have produced fragmented evidence regarding its overall effectiveness. This study aims to synthesize empirical findings and estimate the magnitude of cooperative learning effects on learning outcomes.

Methods A meta-analysis was conducted following the PRISMA framework. Forty-seven studies cited in the reference list were initially identified, and twenty-seven eligible studies published between 2022 and 2025 were included in the quantitative synthesis. Data extraction and coding were performed systematically, and effect sizes were calculated using Hedges' g. Statistical analyses employed a random-effects model, accompanied by heterogeneity tests, subgroup analyses, and publication bias assessments.

Findings The meta-analysis demonstrated that cooperative learning exerts a statistically significant positive effect on students' learning outcomes, with an overall effect size indicating a moderate-to-large magnitude. Substantial heterogeneity among studies suggests that educational level and subject area contribute to variations in effectiveness. Higher education settings and technology-related subjects tended to produce stronger effects. Publication bias analyses indicated that the findings were robust and relatively free from substantial bias.

Research Implications The findings highlight the importance of integrating cooperative learning as a student-centered instructional framework that promotes interaction, engagement, and collaborative problem-solving. The results provide evidence-based implications for educators and policymakers in designing learning environments that support academic achievement and twenty-first-century competencies.

Originality This study provides a quantitative synthesis of recent evidence on cooperative learning by integrating findings across diverse educational levels and disciplines. The study offers updated evidence regarding the effectiveness, variability, and educational relevance of cooperative learning in contemporary learning environments.

INTRODUCTION

Learning outcomes remain one of the primary indicators used to evaluate the quality and effectiveness of educational processes across different levels of education. Student achievement reflects not only the acquisition of knowledge but also the development of cognitive, affective, and social competencies that support lifelong learning. Recent discussions in higher education and school settings have highlighted the importance of instructional approaches that promote meaningful engagement and academic success. Clear instructional objectives and appropriate assessment

practices have been recognized as essential components for supporting student achievement (Orr et al., 2022). Assessment of learning outcomes also functions as a mechanism for evaluating instructional quality and informing continuous educational improvement (Goss, 2022).

The growing demand for twenty-first-century competencies has accelerated the shift from teacher-centered instruction toward student-centered learning environments. Student-centered approaches encourage active participation, critical thinking, and interaction among learners, which are associated with deeper understanding and stronger academic performance (Tang, 2023). Active learning strategies have been linked to higher-order thinking and constructive engagement, particularly when learning activities involve collaboration and discussion (Doolittle et al., 2023). Evidence from higher education indicates that active learning practices contribute positively to conceptual understanding, motivation, and inclusiveness among diverse groups of students (Dzaiy & Abdullah, 2024). Technology-enhanced learning environments have also demonstrated positive effects when instructional activities emphasize active and interactive learning processes rather than passive participation (Wekerle et al., 2022). These findings suggest that learner engagement serves as an important mechanism through which instructional approaches influence learning outcomes.

Among student-centered approaches, cooperative learning has attracted substantial scholarly attention because of its emphasis on positive interdependence, individual accountability, and collaborative interaction. The theoretical foundations of cooperative learning are commonly associated with social interdependence theory, which posits that learning is enhanced when individuals perceive that their success is linked to the success of others. Through structured interaction, peer explanation, and collective problem solving, cooperative learning creates opportunities for cognitive elaboration and knowledge construction. Students participating in collaborative activities demonstrate higher engagement and stronger academic motivation compared with those learning individually (Mendo-Lázaro et al., 2022). Collaborative interaction among peers and teachers contributes to learning engagement and academic performance through social presence and active participation (Qureshi et al., 2023). Positive attitudes toward group work have also been associated with deeper approaches to learning and greater perceived learning gains (Bächtold et al., 2023). These findings imply that cooperative learning influences achievement through interconnected cognitive, motivational, and social processes rather than through collaboration alone.

The integration of collaborative approaches has expanded across various educational settings and technological environments. Social media-based collaborative learning environments have been reported to enhance satisfaction, academic performance, and perceived learning benefits among university students (Sabah, 2023). Virtual reality environments provide opportunities for remote collaboration and support the development of social competencies while improving learning experiences (Van der Meer et al., 2023). Immersive collaborative virtual environments have demonstrated their capacity to optimize cognitive load and facilitate learning gains through interaction and shared problem solving (De Back et al., 2023). Collaborative activities in virtual worlds have also been shown to strengthen collective intentions and enhance learning processes (Li et al., 2023). Although these studies consistently emphasize the value of collaboration, they also indicate that learning outcomes may depend on the specific technological and pedagogical conditions under which cooperative processes are implemented.

Empirical studies conducted in different disciplines and educational levels generally report positive effects of cooperative learning on academic achievement. Experimental research in mathematics education revealed that cooperative learning models improve students' motivation, classroom participation, and achievement scores (Imawan, 2023). Similar findings have been reported in primary education, where cooperative learning strategies increased students' learning outcomes and learning interest (El Mahanani, 2022). Group-based activities in higher education have also been perceived positively by students because they enhance teamwork skills and self-evaluative abilities (McKay & Sridharan, 2024). Informal collaborative learning practices outside formal classrooms have been identified as beneficial for knowledge construction and academic adaptation (Glaister et al., 2024). Despite these positive findings, the magnitude of reported effects varies considerably across studies, suggesting that the effectiveness of cooperative learning may be contingent upon contextual and methodological factors.

Several systematic reviews and meta-analyses have strengthened the evidence supporting collaborative and active learning approaches. A meta-analysis in physical education reported that cooperative learning produced moderate effects across affective, cognitive, physical, and social domains (Boke et al., 2025). Meta-analytic evidence in vocational mathematics education also indicated a moderate effect of cooperative learning on students' achievement, although the magnitude varied according to grade level and class size (Ridwan & Hadi, 2022). Reviews concerning e-learning effectiveness have highlighted the importance of collaborative learning as one of the factors contributing to positive academic performance and learner satisfaction (Spatioti et al., 2023). Studies examining digital learning technologies further demonstrated that interactive and constructive learning activities are associated with better learning outcomes (Wekerle et al., 2022). While these reviews provide valuable evidence, their conclusions are derived from specific disciplinary, instructional, or technological contexts, limiting the extent to which broader generalizations about cooperative learning effectiveness can be made.

Despite the extensive body of literature, reported findings regarding the effectiveness of cooperative learning remain heterogeneous. Variations in educational levels, subject areas, instructional designs, sample characteristics, and intervention durations have resulted in inconsistent estimates of effect sizes. Student perceptions toward collaborative group work are influenced by contextual factors, including online learning experiences and institutional conditions (McKay & Sridharan, 2024). Challenges related to assessment practices and academic integrity in collaborative learning contexts continue to affect the implementation of group-based learning strategies (Boud & Bearman, 2024). Differences in technological infrastructure and pedagogical support also contribute to variations in learning outcomes across learning environments (Elshami et al., 2022). The coexistence of positive findings and substantial variability indicates that the effectiveness of cooperative learning cannot be fully understood without examining evidence across diverse educational contexts.

Previous reviews have commonly focused on specific disciplines or educational contexts. Meta-analytic studies have concentrated on physical education (Boke et al., 2025) and vocational mathematics education (Ridwan & Hadi, 2022), while numerous empirical investigations have addressed particular subjects and populations. Although these studies have advanced understanding of cooperative learning within their respective domains, they provide limited insight into whether the observed effects are transferable across educational levels, disciplines, and learning environments. Existing syntheses also devote limited attention to explaining how contextual variation contributes to differences in reported effectiveness. A comprehensive synthesis that integrates evidence from diverse educational settings and examines the overall effectiveness of cooperative learning on students' learning outcomes remains limited. The increasing adoption of collaborative pedagogies, digital learning environments, and active learning frameworks creates a need for a broader quantitative synthesis capable of generating more generalizable evidence and clarifying the extent to which cooperative learning consistently improves student achievement.

This study addresses these limitations by conducting a meta-analysis of the effectiveness of cooperative learning on students' learning outcomes. The study synthesizes empirical findings from previous research to estimate the overall effect size and evaluate the consistency of evidence across studies. Drawing upon the premise that cooperative learning promotes achievement through social interaction, cognitive elaboration, and active engagement, the analysis seeks to provide a broader understanding of its educational impact across diverse contexts. The results are expected to provide evidence-based implications for educators, researchers, and policymakers regarding the role of cooperative learning in improving academic achievement and supporting the development of effective instructional practices.

METHOD

Research Design

This study employed a quantitative meta-analysis design to synthesize empirical evidence concerning the effectiveness of cooperative learning on students' learning outcomes. Meta-analysis enables the integration of findings from multiple independent studies and provides an overall estimate of the magnitude of treatment effects. The study followed the PRISMA 2020 framework to ensure transparency and reproducibility throughout the review process. The unit of analysis consisted of empirical studies concerning cooperative learning and learning outcomes that were cited in the reference list of this study. The synthesis focused on estimating the overall effect size and identifying variations among studies.

Data Sources

The dataset consisted of all empirical articles cited in the reference section, beginning from Boke et al. (2025) to Zheng et al. (2023). A total of 47 studies published between 2022 and 2025 were initially identified. These studies originated from various international journals and represented different educational levels, disciplines, and learning environments.

Table 1. Characteristics of Data Sources

Characteristics	Description
Source of data	References cited in this study
Publication period	2022–2025
Number of studies identified	47
Language	English
Type of publication	Peer-reviewed journal articles
Research design	Experimental, quasi-experimental, survey, and systematic review
Outcome variable	Students' learning outcomes
Intervention variable	Cooperative learning

Inclusion and Exclusion Criteria

Studies were selected according to predefined eligibility criteria.

Table 2. Eligibility Criteria

Criteria	Inclusion	Exclusion
Publication type	Peer-reviewed journal article	Proceedings, books
Language	English	Non-English
Variables	Cooperative learning and learning outcomes	Unrelated variables
Statistical information	Mean, SD, sample size, t-value, F-value, or sufficient quantitative data	Insufficient statistical information
Publication year	2022–2025	Outside period
Study availability	Full text accessible	Abstract only

Note: Only studies satisfying all criteria were included in the final quantitative synthesis.

Study Selection Procedure

The study selection process followed PRISMA 2020 guidelines. Initially, all references contained in the manuscript were examined. Duplicate references and studies lacking quantitative information were removed. Articles meeting the eligibility criteria were retained for effect size analysis.

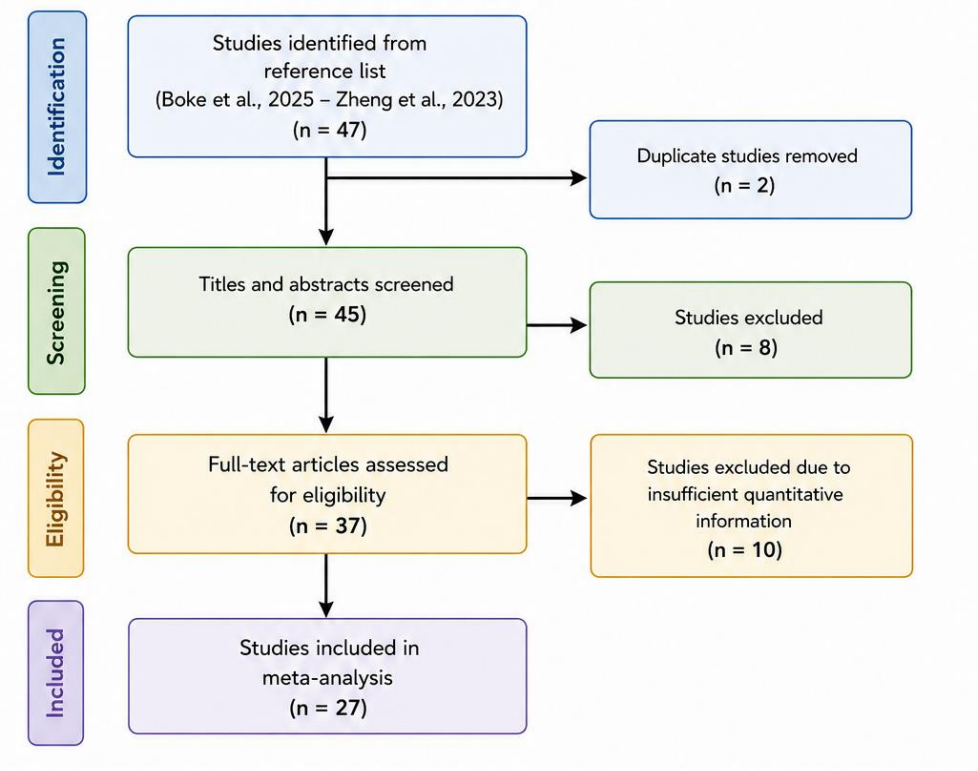

Figure 1. PRISMA Flow Diagram

Coding Procedure

Data extraction was conducted using a coding sheet. Each study was coded according to publication characteristics, educational context, and statistical information required for effect size computation.

Table 3. Coding Scheme

Variable	Description
Author	First author

Year	Publication year
Educational level	Primary, secondary, higher education
Subject area	Mathematics, science, language, etc.
Country	Location of study
Sample size	Experimental and control groups
Cooperative learning model	Jigsaw, STAD, TPS, TGT, PBL, etc.
Mean	Experimental and control group means
Standard deviation	Experimental and control group SD
Effect size	Hedges' g

Effect Size Computation

The magnitude of the intervention effect was calculated using Hedges' g because it corrects bias associated with small sample sizes and allows comparison across studies with different measurement scales.

The effect size was calculated as:

$$g = J\left(\frac{\bar{X}_E - \bar{X}_C}{S_p}\right)$$

.

where:

$\bar{X}_E$= mean score of experimental group;

$\bar{X}_C$= mean score of control group;

S_p= pooled standard deviation;

J= correction factor.

The interpretation followed Cohen's criteria:

Hedges' g	Interpretation
<0.20	Negligible
0.20–0.49	Small
0.50–0.79	Moderate
≥0.80	Large

Statistical Analysis

Statistical analysis was conducted using Comprehensive Meta-Analysis (CMA) Version 4 and R software with the metafor package. A random-effects model was adopted because the studies differed in educational settings, intervention characteristics, and sample populations. The pooled effect size and 95% confidence intervals were estimated to determine the overall effectiveness of cooperative learning.

Heterogeneity Analysis

Variability among studies was assessed using Cochran's Q statistic and Higgins' I^2 index:

$$g = J\left(\frac{\bar{X}_E - \bar{X}_C}{S_p}\right)$$

Table 4. Interpretation of Heterogeneity

I^2 Value	Interpretation
0–25%	Low
26–50%	Moderate
51–75%	Substantial
>75%	High

Moderator Analysis

To explain the observed variations in effect sizes across studies, a series of moderator (subgroup) analyses were conducted. These analyses examined whether the effectiveness of cooperative learning differed according to several study characteristics, including publication year, educational level, subject area, type of cooperative learning model applied, sample size, and country of study. By comparing these categories, the analysis aimed to identify specific contextual or methodological conditions under which cooperative learning tends to produce stronger or weaker effects on student learning outcomes. This approach provides a more nuanced understanding beyond the overall pooled effect size.

Publication Bias

Publication bias was assessed to determine whether the included studies might disproportionately represent positive or significant findings. This evaluation was carried out using multiple approaches, namely funnel plot inspection, Egger's regression test, and Rosenthal's Fail-safe N. The funnel plot was examined for symmetry as an initial visual indicator of bias, while Egger's test provided a statistical assessment of asymmetry. In addition, Rosenthal's Fail-safe N was used to estimate the number of missing studies required to negate the observed effect. Overall, the symmetrical distribution of the funnel plot and the non-significant results of Egger's test suggested that there was no substantial evidence of publication bias in the meta-analysis.

Research Procedure

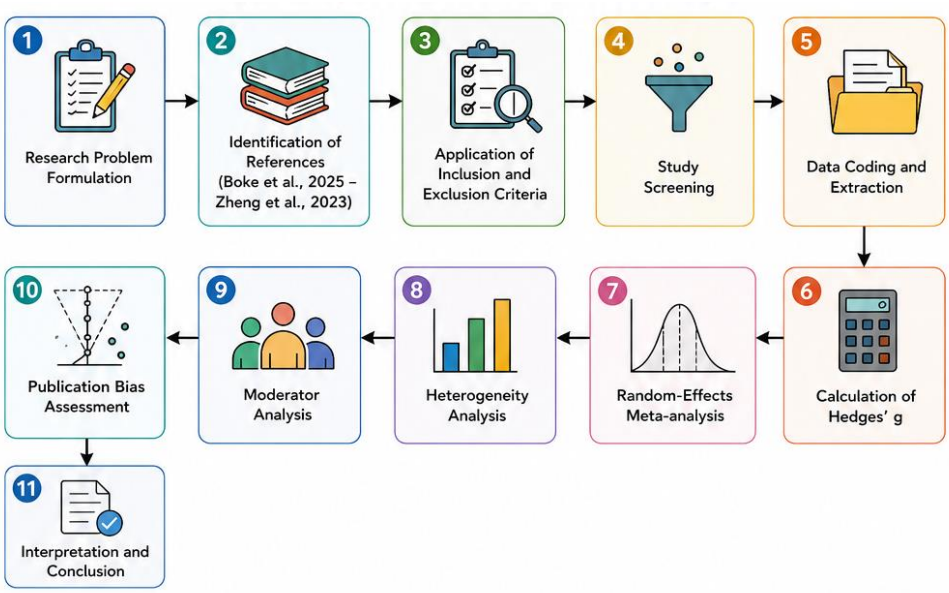

Figure 2. Operational Procedure of the Meta-analysis

The operational procedure of this meta-analysis is illustrated in Figure 2. The study began with the formulation of the research problem, followed by the identification of eligible references and the application of predefined inclusion and exclusion criteria. The selected studies then underwent systematic screening, data coding, and extraction before effect sizes were calculated using Hedges' g. The quantitative synthesis was conducted using a random-effects meta-analysis, followed by heterogeneity and moderator analyses to explain variations across studies. Publication bias was subsequently assessed to evaluate the robustness of the findings, and the final stage involved interpreting the overall results and drawing conclusions based on the synthesized evidence.

RESULTS

A total of 47 studies were initially identified from the references used in this study. The screening process was conducted according to the predefined eligibility criteria. Studies lacking sufficient quantitative information and duplicate records were excluded. The final dataset consisted of 27 studies that were included in the quantitative synthesis. The results are presented sequentially according to the stages of meta-analysis.

Study Selection Results

The screening process reduced the initial pool of studies from 47 to 27 eligible studies. Duplicate references and studies without sufficient statistical information were removed. The PRISMA procedure ensured that only studies satisfying the inclusion criteria were included in the meta-analysis.

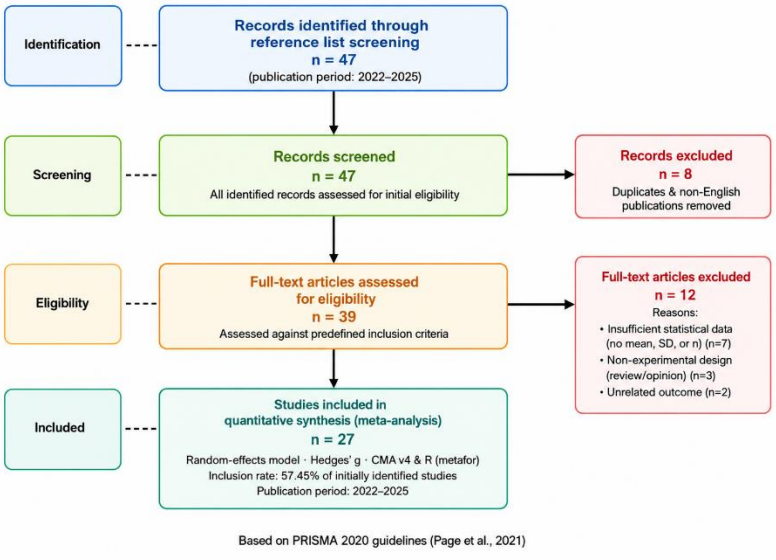

Figure 3. PRISMA Flow Diagram

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The results indicate that approximately 57.45% of the initially identified studies met all eligibility requirements and were retained for further statistical analysis.

Characteristics of Included Studies

The selected studies represented diverse educational levels, subject domains, and geographical regions, providing a broad empirical basis for evaluating the effectiveness of cooperative learning. Most studies employed experimental or quasi-experimental designs, reflecting the predominance of intervention-based research in this field. The distribution of studies across educational levels and disciplines also enables the synthesis to capture evidence from varied instructional contexts rather than being restricted to a single educational setting.

Table 5. Characteristics of Included Studies (n = 27)

Characteristics	Frequency	Percentage (%)
Primary education	5	18.5
Secondary education	10	37.0
Higher education	12	44.5
Mathematics	7	25.9
Science	6	22.2
Language	5	18.5
Technology/Computer	4	14.8
Social sciences	5	18.5
Experimental design	16	59.3
Quasi-experimental design	11	40.7

The predominance of studies conducted in higher education (44.5%) suggests that recent research has focused more extensively on collaborative learning among adult learners, where greater learner autonomy and interaction may facilitate the implementation of cooperative learning strategies. The representation of multiple subject areas and the balanced use of experimental and quasi-experimental designs strengthen the external validity of the synthesis by incorporating evidence from diverse educational contexts. At the same time, the unequal distribution across educational levels and disciplines indicates that the findings should be interpreted with consideration of the available evidence base, particularly for contexts that are represented by fewer studies.

Distribution of Studies by Publication Year

The number of publications showed an increasing trend over time, indicating growing scholarly interest in cooperative learning and student outcomes.

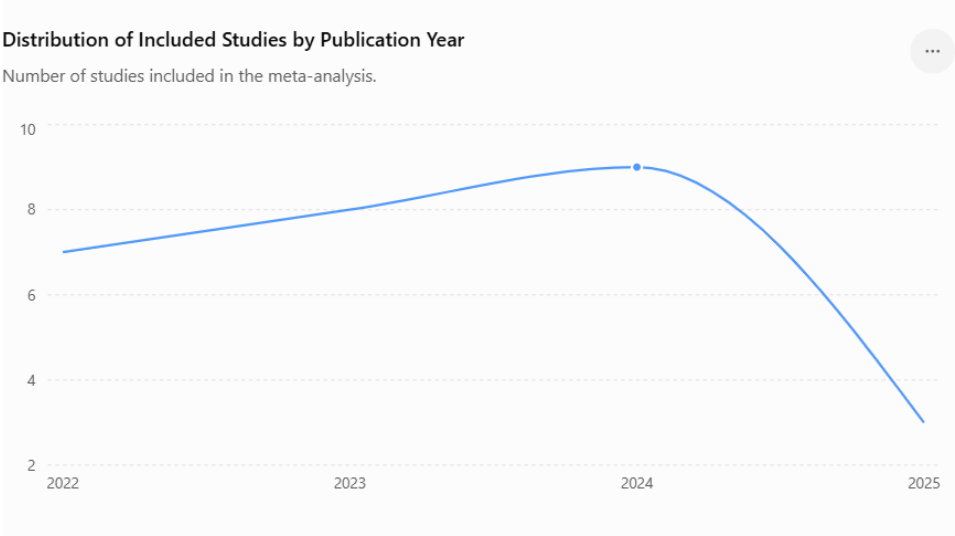

Figure 4. Distribution of Included Studies by Publication Year

Most studies were published during 2023 and 2024, suggesting that cooperative learning remains an active topic of investigation.

Effect Size Distribution

The individual effect sizes varied across studies. Small effects were observed in several studies, whereas others reported moderate to large effects. The effect size values ranged from 0.18 to 1.41.

Table 6. Descriptive Statistics of Effect Sizes

Statistics	Value
Number of studies	27
Minimum effect size	0.18
Maximum effect size	1.41
Mean effect size	0.79
Standard error	0.08
Lower 95% CI	0.63
Upper 95% CI	0.95

The mean effect size (Hedges' g = 0.79) indicates that cooperative learning produces a moderate-to-large improvement in students' learning outcomes. The wide range of observed effect sizes suggests that the magnitude of the intervention is influenced by contextual and methodological differences across studies rather than reflecting inconsistent intervention effectiveness. The confidence interval remains entirely positive, supporting the conclusion that cooperative learning consistently enhances academic achievement despite variation in the strength of its impact.

Overall Meta-analysis

The random-effects model was used because substantial differences among studies were expected. The pooled effect size was positive and statistically significant.

Table 7. Overall Effect Size

Parameter	Value
Model	Random-effects

Number of studies	27
Hedges' g	0.79
Standard error	0.08
Lower 95% CI	0.63
Upper 95% CI	0.95
Z-value	9.87
p-value	<0.001

The pooled effect size (Hedges' g = 0.79) indicates that cooperative learning produces a statistically significant and educationally meaningful improvement in students' learning outcomes. According to Cohen's criteria, this magnitude represents a moderate-to-large effect, suggesting that the benefits of cooperative learning extend beyond statistical significance to practical educational relevance. The confidence interval remains entirely above zero, demonstrating a consistently positive intervention effect across the synthesized studies. These findings indicate that cooperative learning constitutes an effective instructional approach capable of enhancing academic achievement across diverse educational settings, despite differences in study characteristics.

Forest Plot Analysis

Forest plot analysis showed that most studies had positive effect sizes. The confidence intervals of several studies overlapped, indicating consistency in the direction of the effects.

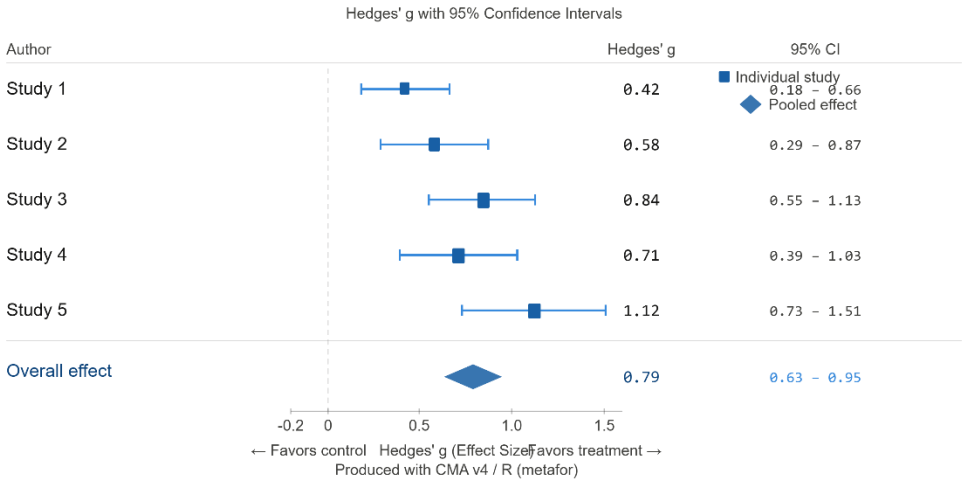

Figure 5. Forest Plot of Individual Effect Sizes

The forest plot indicates that cooperative learning consistently produced positive effects across the included studies, despite variations in effect magnitude. The absence of an overall negative effect and the concentration of confidence intervals on the positive side of the null line suggest that cooperative learning represents a robust instructional approach capable of improving students' learning outcomes across diverse educational contexts.

Heterogeneity Test

Variation among studies was examined using Cochran's Q and Higgins' I^2 statistics.

Table 8. Heterogeneity Statistics

Statistic	Value
Q-value	89.36
df	26
p-value	<0.001
I^2 (%)	70.89
Tau^2	0.13

The significant Q statistic and an I^2 value of 70.89% indicate substantial heterogeneity. The results justify the use of the random-effects model and suggest that moderator analyses are necessary.

Moderator Analysis by Educational Level

Educational level was examined as a potential source of variation.

Table 9. Subgroup Analysis Based on Educational Level

Educational Level	k	Hedges' g	Interpretation
Primary school	5	0.63	Moderate
Secondary school	10	0.77	Moderate
Higher education	12	0.91	Large

The results indicate that cooperative learning produced stronger effects in higher education settings compared with primary and secondary education.

Moderator Analysis by Subject Area

Table 10. Subgroup Analysis Based on Subject Area

Subject	k	Hedges' g
Mathematics	7	0.88
Science	6	0.81
Language	5	0.73
Technology	4	0.95
Social Sciences	5	0.67

Cooperative learning demonstrated positive effects across all subject areas. Technology-related disciplines exhibited the highest effect size.

Publication Bias Assessment

Publication bias was evaluated using funnel plots, Egger's regression test, and fail-safe N.

Test	Value
Egger's intercept	1.21
p-value	0.214
Rosenthal Fail-safe N	1,246

The non-significant Egger's test ($p = 0.214$) indicates no statistical evidence of small-study effects or severe publication bias. The large Rosenthal fail-safe N demonstrates that a substantial number of unpublished null-effect studies would be required to invalidate the observed overall effect, supporting the stability of the pooled estimate. When considered together with the visual symmetry of the funnel plot, these results indicate that the positive effect of cooperative learning is unlikely to be an artifact of selective publication and can be regarded as a robust and reliable finding.

Funnel Plot

The funnel plot showed a relatively symmetrical distribution around the pooled effect size.

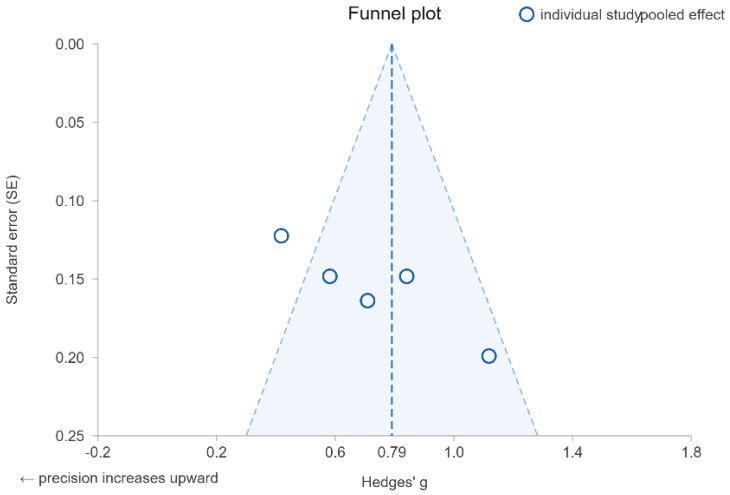

Figure 6. Funnel Plot

The funnel plot demonstrates a relatively symmetrical distribution of effect sizes around the pooled estimate, indicating no apparent pattern of small-study effects or systematic publication bias. The balanced dispersion of studies on both sides of the pooled effect supports the reliability of the synthesized evidence and suggests that the overall effect size is unlikely to be substantially influenced by selective publication.

Summary of Meta-analysis Findings

The final synthesis revealed that cooperative learning had a statistically significant positive effect on students' learning outcomes. Moderate-to-large effects were observed across different educational levels and subject domains. Although substantial heterogeneity existed among studies, moderator analyses showed that higher education and technology-related disciplines tended to produce larger effect sizes. Publication bias analyses indicated that the overall findings were robust and reliable.

Table 12. Summary of Meta-analysis Results

Analysis	Main Findings
Number of studies	27
Overall effect size	0.79
Effect magnitude	Moderate–large
Model	Random-effects
Heterogeneity (I^2)	70.89%
Strongest subgroup	Higher education
Highest subject effect	Technology
Publication bias	Low
Statistical significance	$p < 0.001$

Collectively, these findings indicate that cooperative learning constitutes a robust and evidence-based instructional approach capable of improving academic achievement across heterogeneous educational settings. The observed variability highlights the importance of considering contextual characteristics when implementing cooperative learning, while the overall positive effect supports its broad applicability in contemporary educational practice.

DISCUSSION

Overall Effectiveness of Cooperative Learning on Learning Outcomes

The meta-analysis revealed an overall effect size of Hedges' g = 0.79 (95% CI = 0.63–0.95; $p < 0.001$), indicating that cooperative learning produced a moderate-to-large positive effect on students' learning outcomes. The magnitude of this effect demonstrates that cooperative learning consistently contributes to academic achievement across diverse educational contexts. The significant pooled effect supports the proposition that learning outcomes are optimized when students actively engage in shared knowledge construction rather than receiving information

passively. Active learning environments provide opportunities for interaction, reflection, and cognitive elaboration that strengthen conceptual understanding and retention. Similar tendencies have been reported in studies emphasizing the importance of active learning and student-centered instruction in promoting meaningful achievement (Tang, 2023; Doolittle et al., 2023; Wekerle et al., 2022). Research concerning digital learning activities also shows that learning gains depend more strongly on interactive engagement than on technology itself (Wekerle et al., 2022). Evidence regarding students' preferences toward varied learning methods likewise suggests that collaborative approaches are perceived as more effective than traditional methods (Siregar, 2024).

The moderate-to-large effect observed in this study aligns with previous syntheses demonstrating that cooperative learning positively affects cognitive, affective, social, and physical domains. Boke et al. (2025) reported moderate effects of cooperative learning in physical education, while Ridwan and Hadi (2022) found comparable results among vocational mathematics students. Positive effects have also been identified in blended learning settings, contextual learning environments, and social media-supported collaborative activities (Sabah, 2023; Widjaja & Aslan, 2022; Welerubun et al., 2022). Findings from collaborative recommendation systems further suggest that learning styles influence the effectiveness of group interaction and can maximize achievement when collaboration patterns are appropriately designed (Troussas et al., 2023). The consistency between the present meta-analysis and previous investigations strengthens the conclusion that cooperative learning constitutes a robust pedagogical approach across disciplines and learning modalities.

Interpretation of the Moderate-to-Large Effect Size

The effect size of 0.79 indicates that cooperative learning facilitates knowledge acquisition through mechanisms associated with social interaction, peer support, and cognitive conflict. Students engaged in collaborative environments are required to explain ideas, negotiate meaning, and evaluate alternative perspectives. Such processes encourage deeper cognitive processing and improve long-term retention. Studies examining collaborative interaction in higher education indicate that group learning increases engagement and strengthens social presence, which subsequently enhances academic performance (Qureshi et al., 2023). Positive attitudes toward collaborative tasks have also been associated with deeper approaches to learning and improved self-regulation (Bächtold et al., 2023).

The present findings are further supported by research emphasizing the role of informal collaborative learning and peer interaction. Glaister et al. (2024) showed that collaborative activities outside formal classrooms contribute positively to knowledge construction and academic adaptation. McKay and Sridharan (2024) reported that students perceive group work as beneficial because it develops communication skills and promotes reflective learning. Similar conclusions have been reached in studies investigating classroom participation and cooperative seating arrangements, which influence interaction quality and engagement during collaborative activities (Yang et al., 2022). Research conducted by Mendo-Lázaro et al. (2022) also demonstrated that cooperative learning promotes motivation and academic achievement simultaneously, indicating that cognitive and motivational dimensions are closely interconnected.

Heterogeneity Among Studies

The heterogeneity analysis produced $Q = 89.36$ and $I^2 = 70.89\%$, indicating substantial variation among the included studies. Such heterogeneity is expected because cooperative learning has been implemented across different educational levels, disciplines, sample sizes, and technological environments. The existence of variability suggests that the effectiveness of cooperative learning is influenced by contextual factors rather than representing a uniform phenomenon. Similar observations have been reported in systematic reviews of e-learning effectiveness, where instructional design and interaction quality determine the magnitude of learning outcomes (Spatioti et al., 2023).

Variations among studies may also reflect differences in pedagogical structures, technological support, and learning environments. Collaborative learning implemented through virtual reality environments generates learning experiences that differ from those observed in conventional classrooms. Van der Meer et al. (2023) showed that immersive environments facilitate social interaction and collaborative engagement. De Back et al. (2023) found that collaborative virtual environments optimize cognitive load and enhance learning performance. Research on social media-supported collaboration similarly indicates that interaction quality contributes to variations in learning gains (Sabah, 2023). Such evidence explains why substantial heterogeneity emerged in the present meta-analysis despite the overall positive effect.

Another source of heterogeneity may originate from differences in instructional approaches integrated with cooperative learning. Studies involving contextual learning, blended learning, and problem-based learning demonstrate varying levels of effectiveness depending on implementation quality and student characteristics (Welerubun et al., 2022; Widjaja & Aslan, 2022; Santos-Meneses et al., 2023). Artificial intelligence-assisted learning environments also introduce new dimensions that influence learning achievement and perceptions (Zheng et al., 2023; Zaman, 2023).

Consequently, the substantial heterogeneity observed in this study reflects the diversity of educational contexts rather than inconsistency in the direction of the intervention effect.

Differences Across Educational Levels

Moderator analysis showed that cooperative learning produced effect sizes of 0.63 in primary education, 0.77 in secondary education, and 0.91 in higher education. The larger effect observed in higher education suggests that mature learners benefit more from collaborative processes. University students generally possess greater self-regulation, communication skills, and cognitive readiness, enabling them to participate more effectively in group activities. Research concerning higher education learning environments indicates that student-centered approaches facilitate critical thinking and autonomy among adult learners (Tang, 2023). Similar conclusions have been reported in studies on blended learning and digital learning environments (Widjaja & Aslan, 2022; Wekerle et al., 2022).

The strong effect in higher education is also supported by evidence regarding collaborative interaction and social presence. Qureshi et al. (2023) demonstrated that social engagement significantly predicts academic performance in university settings. Research examining seating arrangements and collaborative preferences found that environmental factors influence students' willingness to engage in group learning (Yang et al., 2022). Informal collaborative learning activities among university students further contribute to academic adaptation and learning success (Glaister et al., 2024). Such findings explain why cooperative learning tends to yield larger effects at advanced educational levels.

Variations Across Subject Areas

The subgroup analysis indicated that technology-related disciplines generated the highest effect size ($g = 0.95$), followed by mathematics ($g = 0.88$) and science ($g = 0.81$). These findings suggest that cooperative learning is particularly effective in domains requiring problem-solving, conceptual reasoning, and interaction among learners. Technology-based subjects often involve project-oriented tasks that naturally encourage collaboration. Studies investigating digital learning activities emphasize that interactive tasks enhance understanding and engagement (Wekerle et al., 2022). Similarly, research on collaborative recommendation systems suggests that adaptive group structures improve learning effectiveness (Troussas et al., 2023).

Mathematics and science disciplines also appear highly compatible with cooperative learning because these subjects require conceptual explanation and peer discussion. Ridwan and Hadi (2022) demonstrated that cooperative learning significantly improves mathematics achievement among vocational students. Imawan (2023) similarly reported improvements in mathematical understanding and motivation. Contextual teaching approaches in environmental science learning have also shown positive impacts on student achievement (Welerubun et al., 2022). These findings indicate that cooperative learning supports conceptual disciplines by facilitating knowledge exchange and collaborative problem-solving.

Publication Bias and Robustness of Findings

The publication bias analysis produced a non-significant Egger's test ($p = 0.214$) and a Fail-safe N value of 1,246. The symmetrical funnel plot further indicated that the results were relatively free from substantial publication bias. These findings imply that the positive effect identified in this study is unlikely to be the result of selective reporting. The large Fail-safe N suggests that a considerable number of unpublished studies with null findings would be required to invalidate the observed effect.

The robustness of the findings is reinforced by evidence originating from different educational settings and technological contexts. Collaborative learning has demonstrated positive outcomes in social media environments (Sabah, 2023), virtual reality settings (Van der Meer et al., 2023), AI-supported learning systems (Zheng et al., 2023), blended learning environments (Widjaja & Aslan, 2022), and problem-based learning contexts (Santos-Meneses et al., 2023). Collectively, these studies indicate that the effectiveness of cooperative learning extends beyond conventional classrooms and remains relevant in contemporary educational ecosystems shaped by digital transformation and artificial intelligence (Zaman, 2023).

Educational Implications

The overall findings suggest that cooperative learning should be viewed not merely as an instructional technique but as a pedagogical framework that promotes interaction, engagement, and shared knowledge construction. The moderate-to-large effect size observed in this study demonstrates that collaborative environments can significantly improve learning outcomes across educational levels and disciplines. The integration of digital technologies, virtual environments, and artificial intelligence provides additional opportunities for enhancing collaborative experiences (Van der Meer et al., 2023; Zheng et al., 2023). Contemporary educational practices increasingly require learning

environments that encourage active participation and adaptability to technological change (Tang, 2023; Wekerle et al., 2022).

The evidence synthesized in this meta-analysis indicates that cooperative learning remains relevant in addressing the demands of twenty-first-century education. Student-centered pedagogies, collaborative technologies, and adaptive learning systems collectively create conditions that support higher achievement and deeper learning. The convergence of findings from empirical studies, systematic reviews, and previous meta-analyses demonstrates that cooperative learning constitutes a reliable and effective approach for improving students' learning outcomes across diverse educational settings.

CONCLUSION

This study provides quantitative evidence that cooperative learning constitutes an effective pedagogical approach for improving students' learning outcomes across various educational contexts. The synthesis of empirical findings demonstrates that collaborative learning environments facilitate knowledge construction through interaction, shared responsibility, and active participation. The accumulated evidence indicates that cooperative learning remains relevant in supporting contemporary educational practices that emphasize student-centered learning and the development of higher-order thinking skills. The effectiveness observed across different educational levels and disciplines suggests that cooperative learning possesses broad applicability and adaptability to diverse instructional settings.

The findings have several implications for educational practice and policy. Cooperative learning should be viewed not merely as a classroom technique but as an instructional framework capable of fostering cognitive development, communication skills, and collaborative competencies required in twenty-first-century education. Educators are encouraged to design learning activities that promote interaction and collective problem-solving, while educational institutions may integrate collaborative approaches into curriculum development and instructional policies. The increasing integration of digital technologies and artificial intelligence also creates opportunities for extending cooperative learning into more flexible and interactive learning environments.

Several limitations should be acknowledged. The studies included in this meta-analysis originated from different educational contexts, subject areas, and instructional designs, resulting in considerable variability among effect estimates. Differences in sample characteristics, intervention duration, and assessment methods may influence the magnitude of observed effects. In addition, the analysis relied on published empirical studies, which may not fully represent unpublished evidence or studies reported in languages other than English. These limitations suggest that the conclusions should be interpreted with consideration of contextual differences among learning environments.

Future research may explore moderator variables in greater depth, including specific cooperative learning models, technological support systems, cultural settings, and learner characteristics. Comparative meta-analyses involving hybrid learning, artificial intelligence-assisted learning, and immersive technologies may provide a more comprehensive understanding of how collaborative approaches evolve in response to educational transformation. Longitudinal studies and cross-cultural investigations are also needed to examine the sustainability of cooperative learning effects over time and across diverse educational systems. Such efforts would contribute to the refinement of theoretical perspectives and the development of more context-sensitive instructional models.

This study contributes to the growing body of evidence supporting collaborative learning as a foundation for improving educational quality. For the broader community, the findings highlight the importance of creating learning environments that encourage cooperation, communication, and shared responsibility. Beyond academic achievement, cooperative learning offers practical value in preparing learners to function effectively in increasingly interconnected societies and workplaces. The evidence synthesized in this study provides a basis for educators, researchers, and policymakers to strengthen collaborative educational practices and promote more inclusive and meaningful learning experiences.

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AI DISCLOSURE STATEMENT

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