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The Effectiveness of the Constructivist Approach on Students' Achievement in Mathematics: A Meta-Analysis

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Abstract
Mathematics learning often challenges students, as sustaining engagement, motivation, and understanding of abstract concepts can be difficult. Constructivist approaches have emerged as powerful approaches to enhance meaningful learning, promote active participation, and improve problem-solving skills in mathematics. This study examined the overall effects of constructivist approaches on mathematics learning across educational levels, identified the most effective strategies, and assessed the reliability of findings. From an initial screening of 3,000 studies, 20 were selected following the PRISMA process and evaluated using the CASP checklist. Descriptive and inferential statistics analyzed the prevalence and effectiveness of constructivist approaches, while subgroup analyses compared outcomes across different educational settings. Heterogeneity, stability, and publication bias were examined using standard procedures, with all results generated in JASP for transparency and reproducibility. The findings indicated a moderate-to-large overall effects of constructivist approaches on mathematics learning (M = 0.400, 95% CI [0.372–0.427]), with consistently positive outcomes across studies. Inquiry-Based Instruction (35%) was identified as the most effective approach, followed by Collaborative Learning (25%), Problem-Based Learning (25%), and Scaffolding (15%). No publication bias confirmed the reliability of these results. Thus, constructivist approaches are effective instructional approaches that enhance students' overall mathematics achievement. Educators are encouraged to integrate these approaches to foster active, inquiry-driven, and collaborative learning environments in mathematics classrooms.

Keywords: Effectiveness, Constructivist Approach, Mathematics Education, Quantitative Study, Mathematics Achievement

1. Introduction

The teaching strategies that mathematics educators employ play a crucial role in shaping how students understand mathematical concepts. Traditional methods often emphasize rote learning and procedural fluency, which may lead students to view mathematics as abstract and difficult to grasp (Arega *et al*., 2025; Balanlay, 2021) [5, 7]. Consequently, many learners struggle with conceptual understanding, problem-solving, and the ability to apply mathematics in real-world situations. The persistent challenge of low mathematics performance among students, as observed globally and in the Philippines, calls for a paradigm shift toward more student-centered approaches that promote active engagement and deeper understanding (Abao, 2022; Quilloy, 2022) [25, 46].

The constructivist approach to teaching offers a promising pathway to address these challenges. Rooted in the idea that learners actively construct knowledge through experiences and social interactions, constructivism emphasizes meaningful learning through exploration, collaboration, and reflection (Angraini *et al*., 2022; Özkan, 2024) [4, 42]. Within mathematics education, this approach encourages students to make sense of mathematical ideas by connecting them to prior knowledge and real-life contexts. Studies show that constructivist teaching enhances students' problem-solving skills, critical thinking, and academic achievement compared to traditional lecture-based methods (Atteh, 2022 [6]; Ginga *et al*., 2020; Liu *et al*., 2022 [32]).

Globally, empirical evidence supports the effectiveness of constructivist-based instruction in improving mathematics learning outcomes. For instance, Zhu *et al*. (2024) [58] found that first-grade students who experienced a constructivist and collaborative learning environment demonstrated higher mathematical achievement and social awareness. Similarly, Guangbao *et al*. (2021) [20] observed that teachers' constructivist beliefs significantly influence classroom climate and students' performance in mathematics. In engineering and secondary education contexts, constructivist learning also fosters engagement and confidence among students (Özkan, 2024; Uygun *et al*., 2021) [42, 56]. These findings affirm that constructivism not only improves academic performance but also supports the development of essential 21st-century skills such as reasoning, communication, and collaboration (Syamsuddin, 2024) [53].

In the Philippine context, recent studies have applied constructivist strategies to improve mathematics achievement. Abao (2022) [25] implemented a constructivist approach in teaching polynomial functions and segments of circles in a junior high school in Northern Cebu, showing significant gains in learners' understanding and retention. Likewise, Quilloy (2022) [46] explored digital, game-based constructivist activities through the Math-DALI app and found notable improvement in Grade 10 learners' performance. Meanwhile, Ebajan *et al*. (2024) [18] demonstrated that the FRAME strategy that is grounded in feedback and modeling principles aligned with constructivism that can enhanced Grade 9 learners' mathematical achievement. These local studies highlight that constructivist-based learning approaches can effectively engage Filipino students by integrating collaboration, inquiry, and contextualized problem-solving.

Despite growing evidence of the constructivist approach's effectiveness, results across studies remain varied. Some research reports substantial improvements in students' performance, while others indicate modest or context-dependent effects (Adjei, 2023; Akendita *et al*., 2023; Arega *et al*., 2025) [2, 3, 5]. Variations may arise from factors such as implementation fidelity, teacher preparedness, learner characteristics, and learning environments. Given these inconsistencies, a meta-analysis is helpful. Thus, a comprehensive synthesis of findings is essential to determine the overall effectiveness of constructivist approaches in mathematics learning and to identify the conditions under which they are most beneficial.

1.1 Research Objectives

This meta-analysis aims to synthesize existing research on the effects of the constructivist approach on students' achievement in mathematics. Specifically, the study seeks to determine the overall effectiveness of constructivist approaches in enhancing students' achievement in mathematics across different educational levels. Furthermore, it intends to identify which specific constructivist teaching approaches are most effective in improving students' mathematical understanding and performance. Lastly, this meta-analysis seeks to examine the presence of publication bias and assess the consistency and reliability of findings across research.

2. Review of Related Literature

This review of related literature synthesizes global, national, and local studies and reviews related to the constructivist approach in mathematics education. It supports the present meta-analysis objectives which are to: (1) determine the overall effectiveness of constructivist-based instructional strategies in enhancing mathematical learning across educational levels, (2) identify which specific constructivist teaching approaches such as collaborative learning, inquiry-based instruction, scaffolding, and problem-based learning are most effective in improving students' mathematical understanding and performance, and (3) examine publication bias and assess the consistency and reliability of findings across research.

Furthermore, the review draws mainly from the references that are provided (2020–2025) for supporting the stated objectives. The review considers meta-analyses, experimental reviews, and systematic research globally outside the Philippines, nationally within the Philippines, and locally within Cebu so that conclusions support the meta-analytic gap.

2.1 Overall Effectiveness of Constructivist Approaches on Students' Mathematical Achievement Across Educational Levels

Constructivist learning theory emphasizes that learners actively construct knowledge through engagement, interaction, and reflection, rather than passively receiving information. This approach encourages learners to connect new concepts with prior knowledge, solve problems collaboratively, and reflect on their learning experiences. Across educational levels—from elementary to tertiary—many studies worldwide have shown that the constructivist approach strengthens students' mathematical achievement, conceptual understanding, and motivation. It represents a paradigm shift from teacher-centered instruction to learner-centered experiences, fostering critical thinking and deeper comprehension (Arega *et al*., 2025) [5].

2.1.1 Global Perspectives on Constructivist Approaches in Mathematics Education

Globally, the constructivist approach has been widely recognized as an effective strategy for improving learning outcomes in mathematics. Arega *et al*. (2025) [5] conducted a systematic review and concluded that constructivist instructional approaches consistently improve academic performance and conceptual understanding compared to traditional lecture-based methods. Similarly, Zhu *et al*. (2024) [58] examined first-grade students and found that an instructional model grounded in constructivist theory and collaborative learning improved both mathematical learning achievement and social awareness.

In higher education, Liu *et al*. (2022) [32] demonstrated that constructivist teaching in college-level differential equations classes enhanced students' analytical reasoning and problem-solving skills. Moreover, Özkan (2024) [42] found that engineering students valued social constructivist learning environments because they promoted teamwork, engagement, and meaningful understanding of abstract mathematical ideas. These findings are consistent with Guangbao *et al*. (2021) [20], who reported that teachers' constructivist beliefs and classroom climate were positively associated with higher self-efficacy and improved student learning outcomes in mathematics.

Globally, the literature shows that constructivist teaching fosters both cognitive and affective learning dimensions. It strengthens students' confidence, encourages participation, and helps them transfer mathematical knowledge to real-world contexts (Angraini *et al*., 2022) [4]. However, studies also emphasize that teacher guidance, scaffolding, and proper integration of digital tools are crucial in realizing the full benefits of constructivist instruction.

2.1.2 National Perspectives on Constructivist Approaches in Philippine Mathematics Education

In the Philippine context, mathematics education continues to face persistent challenges in students' performance and engagement. As reflected in international assessments like PISA and TIMSS, Filipino learners often struggle to meet proficiency benchmarks in mathematics, which underscores the need for more effective teaching approaches. To address these challenges, several Philippine studies have explored constructivist strategies as alternatives to traditional rote learning.

Balanlay (2021) [7] found that Filipino mathematics teachers who adopted constructivist-oriented instructional practices observed improved student performance, deeper conceptual understanding, and stronger classroom participation. Similarly, Ebajan *et al*. (2024) [18] implemented the Feedback, Reframe, Assess, Model, and Enhance (FRAME) strategy in teaching mathematics and found significant improvements in the performance of ninth-grade students, confirming that active, student-centered learning environments can enhance outcomes.

Moreover, Quilloy (2022) [46] developed the Math-DALI game-based activities, which are grounded in constructivist principles, and discovered that these digital learning tools significantly enhanced Grade 10 learners' mathematical performance and motivation. These studies highlight that the constructivist approach aligns with the Philippines' ongoing curriculum reforms, which emphasize problem-solving, collaboration, and learner autonomy.

2.1.3 Local Perspectives on Constructivist Approaches in Mathematics Education (Cebu)

At the local level, particularly within Cebu, emerging research supports the positive effects of constructivist instruction in mathematics classrooms. Abao (2022) [25] conducted a quasi-experimental study in a Northern Cebu junior high school and found that constructivist teaching of polynomial functions and segments of circles significantly improved students' understanding, participation, and retention compared to traditional instruction. The study demonstrated that when learners engage in exploration and guided discovery, their performance in mathematics increases substantially.

These local findings complement broader national evidence and demonstrate that constructivist methods are adaptable to various classroom contexts, including resource-limited schools. Such research provides strong support for using the constructivist approach not only in metropolitan settings but also in provincial schools across the Philippines, where innovative and student-centered teaching can have transformative impacts on mathematical learning outcomes.

2.1.4 Synthesis of Global, National, and Local Findings

Across global, national, and local levels, consistent evidence supports the effectiveness of constructivist approaches in enhancing mathematical learning outcomes. International research has established strong theoretical and empirical foundations for constructivist learning, demonstrating improvements in problem-solving, reasoning, and engagement. In the Philippine context, constructivist practices have been shown to improve academic performance and motivation while aligning with current educational reforms. Locally, Cebu-based studies confirm that these benefits extend to diverse learning environments and student populations.

Despite these encouraging findings, variations exist depending on educational level, instructional design, and contextual factors such as teacher readiness and resource availability. These variations indicate the need for a comprehensive meta-analysis that synthesizes results from multiple studies to determine the overall effect size of constructivist approaches in mathematics education. Such synthesis can identify which factors most strongly influence effectiveness and provide evidence-based guidance for improving teaching and learning practices across levels and regions.

2.2 Specific Constructivist Teaching Approaches That Enhance Mathematical Understanding

Constructivist pedagogy is composed of diverse instructional approaches that help students build mathematical understanding through exploration, collaboration, and reflection. Among the most commonly used strategies are collaborative learning, inquiry-based learning, scaffolding, and problem-based learning (PBL). These methods share a common goal of positioning students as active participants in constructing knowledge rather than passive recipients of information.

2.2.1 Collaborative Learning

Collaborative learning encourages students to co-construct knowledge through dialogue, teamwork, and shared problem-solving. Zhu *et al*. (2024) [58] conducted an experimental study among first-grade learners and found that students who participated in constructivist-based collaborative learning achieved higher mathematical scores and improved social awareness compared to those taught through direct instruction. Similarly, Guangbao *et al*. (2021) [20] emphasized that collaborative classroom climates enhance teachers' self-efficacy and positively influence students' learning outcomes.

In the Philippines, Quilloy (2022) [46] developed the *Mathematics Digitized Activities for Learners' Intervention (Math-DALI)*, which integrates collaborative digital games into mathematics learning. The study revealed significant improvements in Grade 10 students' problem-solving and engagement. This aligns with Syamsuddin (2024) [53], who highlighted that student-centered and socially interactive learning increases motivation and performance in mathematics.

At the local level, Hinaloc Abao (2022) [25] implemented a constructivist approach in teaching polynomial functions and circle segments among junior high school students in Northern Cebu. The inclusion of peer collaboration and shared exploration improved conceptual understanding and class participation. These findings demonstrate that collaborative learning, when grounded in constructivist principles, fosters both academic and interpersonal growth among learners in mathematics classrooms.

2.2.2 Inquiry-Based Learning

Inquiry-based learning encourages students to explore mathematical ideas by posing questions, forming hypotheses, and testing solutions. Arega *et al*. (2025) [5] found that inquiry-oriented constructivist approaches significantly enhance students' reasoning and critical thinking. Likewise, Chen (2024) [15] reported that inquiry-based instruction improved high school students' mathematical reasoning and critical thinking skills, while Liu *et al*. (2022) [32] observed that exploratory inquiry supported college students' mastery of differential equations through discovery and experimentation.

In the Philippine setting, inquiry-based learning has been recognized as an essential component of student-centered instruction. Balanlay (2021) [7] showed that when teachers encouraged students to investigate mathematical concepts and present their reasoning, achievement levels improved significantly. Similarly, Atteh (2022) [6] emphasized that constructivist strategies rooted in inquiry foster better problem-solving and reflective thinking among pre-service mathematics teachers.

In Cebu, inquiry-based instruction has been applied in secondary classrooms to address persistent learning gaps. Studies such as Hinaloc Abao (2022) [25] demonstrated that when students were guided to explore patterns and relationships through questioning, their understanding of mathematical concepts deepened. These local practices show that inquiry-based learning cultivates independence and curiosity among Cebuano students, contributing to long-term retention of mathematical knowledge.

2.2.3 Scaffolding

Scaffolding is a core constructivist principle that provides structured support to help students progress toward independent problem-solving. Angraini *et al*. (2022) [4] emphasized that teachers' guidance through scaffolding plays a critical role in helping learners internalize complex mathematical concepts. Özkan (2024) [42] also found that scaffolding in constructivist classrooms encourages engagement and collaborative understanding among engineering students.

In the Philippines, Balanlay (2021) [7] noted that mathematics teachers who incorporated scaffolding techniques observed improvements in learners' confidence, persistence, and understanding of abstract ideas. This approach allowed students to gradually take ownership of their learning process. Similarly, Ebajan *et al*. (2024) [18] integrated step-by-step feedback and modeling through their FRAME method, effectively scaffolding students toward better performance and conceptual mastery.

Locally, Hinaloc Abao (2022) [25] provided evidence that structured teacher guidance through scaffolding significantly supported junior high students in Northern Cebu. By offering hints, feedback, and guided examples, students developed greater autonomy and accuracy in solving complex problems. This shows that effective scaffolding practices can enhance both confidence and competence in mathematical learning at the local level.

2.2.4 Problem-Based Learning (PBL)

Problem-Based Learning situates students in authentic, real-world mathematical problems that require reasoning, exploration, and collaboration. Arega *et al*. (2025) [5] identified PBL as one of the most effective constructivist strategies, producing higher achievement scores and better retention. Similarly, Atteh (2022) [6] found that pre-service teachers who engaged in PBL demonstrated improved problem-solving skills and deeper conceptual understanding of mathematics.

In the Philippines, several studies have explored the use of PBL in mathematics instruction. Ebajan *et al*. (2024) [18] applied real-life problem contexts through the FRAME model, which mirrors constructivist principles, and reported notable improvements in students' mathematical performance and motivation. Quilloy (2022) [46] also confirmed that contextualized and problem-based digital activities increased engagement and achievement among secondary learners.

Within Cebu, problem-based learning has been implemented in various public and private schools to make mathematics more meaningful and relevant to students' everyday lives. Research conducted by Hinaloc Abao (2022) [25] revealed that exposing students to contextualized problem situations strengthened their analytical reasoning and application of mathematical concepts. These findings affirm that PBL, supported by local initiatives, is a powerful constructivist method that enhances critical thinking and deep understanding in mathematics education.

2.2.5 Summary of Constructivist Approaches

Across global, national, and local studies, constructivist strategies such as collaborative learning, inquiry-based learning, scaffolding, and problem-based learning consistently demonstrate positive effects on students' mathematics achievement, motivation, and engagement. While international studies provide strong theoretical and empirical evidence, Philippine and Cebu-based research affirm that these strategies are adaptable to local contexts and effective in addressing persistent learning challenges. Synthesizing these findings through meta-analysis allows for a clearer understanding of which constructivist practices yield the most significant impact on mathematical achievement across diverse educational settings.

2.3 Examining Publication Bias and Reliability of Findings

To fulfill the objective of assessing the consistency and reliability of findings, this section examines the potential publication bias among studies on the constructivist approach in mathematics education. Globally, meta-analyses have shown that publication bias may occur when studies reporting positive effects of constructivist strategies are more likely to be published than those showing neutral or negative results. Arega *et al*. (2025) [5] observed that while constructivist instructional approaches generally yield positive outcomes, the strength of evidence varies depending on methodological rigor and reporting standards. Similarly, Ginga and Zakariya (2020) [20] and Atteh (2022) [6] found that studies with strong experimental designs tend to report higher effects on mathematics achievement, suggesting that the quality of implementation influences the measured success of constructivist teaching.

Researchers such as Guangbao *et al*. (2021) [20] and Zhu *et al*. (2024) [58] emphasized the importance of consistent data collection and analysis in verifying the reliability of findings. Across countries, studies that included sufficient sample sizes and reliable assessment tools showed more stable results. These findings confirm that constructivist approaches have a consistent positive influence on mathematics learning outcomes when well implemented and properly measured. However, variations in effect sizes across contexts indicate that differences in teacher training, resource availability, and classroom climate can influence outcomes.

At the national level, studies in the Philippines, such as those by Balanlay (2021) [7] and Quilloy (2022) [46], also point out the potential influence of publication bias, since most research published locally reports positive effects of constructivist strategies. These findings may be affected by the tendency to publish successful interventions rather than neutral or negative results. Despite this, the consistency of reported gains in mathematics achievement across Philippine studies adds credibility to the overall effectiveness of the approach.

Locally, in Cebu-based research, Hinaloc Abao (2022) [25] highlighted that while constructivist instruction improves students' problem-solving skills, the effectiveness varies depending on the learners' background and teachers' readiness to apply the method. This variation indicates that contextual and implementation factors play an essential role in shaping outcomes. Hence, this meta-analysis aims to statistically assess the presence of publication bias through effect size comparison and consistency testing. Such analysis ensures that conclusions about the effectiveness of the constructivist approach in mathematics are credible, transparent, and reliable across diverse research contexts.

3. Methodology

According to Borenstein *et al*. (2021) [11], a meta-analysis is a statistical technique that combines results from multiple studies to draw a more reliable conclusion about a particular topic. This study used a meta-analytic approach to examine the effectiveness of the constructivist approach on students' achievement in mathematics by analyzing experimental, quasi-experimental, systematic review, and meta-analysis studies that focused on constructivist strategies such as collaborative, inquiry-based, scaffolding, and problem-based learning. Relevant research from global, national, and local contexts, including studies in the Philippines and Cebu, was synthesized to determine the overall impact of constructivist instruction. This approach aimed to provide a clearer understanding of how constructivist teaching enhances mathematics learning and to offer insights that can guide teachers, curriculum developers, and policymakers in improving mathematics education (Cheung *et al*., 2021; Wang *et al*., 2022) [16, 57].

Search Strategy

A scholarly electronic database search was conducted to find English-language studies related to the Effectiveness of the Constructivist Approach on Students' Achievement in Mathematics, using the Harzing Publish or Perish Version 8 in 2021 software with access to three databases namely Google Scholar, Open Alex, and Crossref. Relevant studies to the Effectiveness of the Constructivist Approach on Students' Achievement in Mathematics, published between 2020-2025, were collected and reviewed. The keywords applied in the three databases (Google Scholar, Open Alex, and Crossref) search via Harzing Publish or Perish Version 8 in 2021 software included: effectiveness, constructivist approach, mathematics education, quantitative study, mathematics achievement. Aside from that, manual searching was also considered to find additional relevant studies within the local and national context. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA 2020) flow diagram was used to systematically organize and document the selection process.

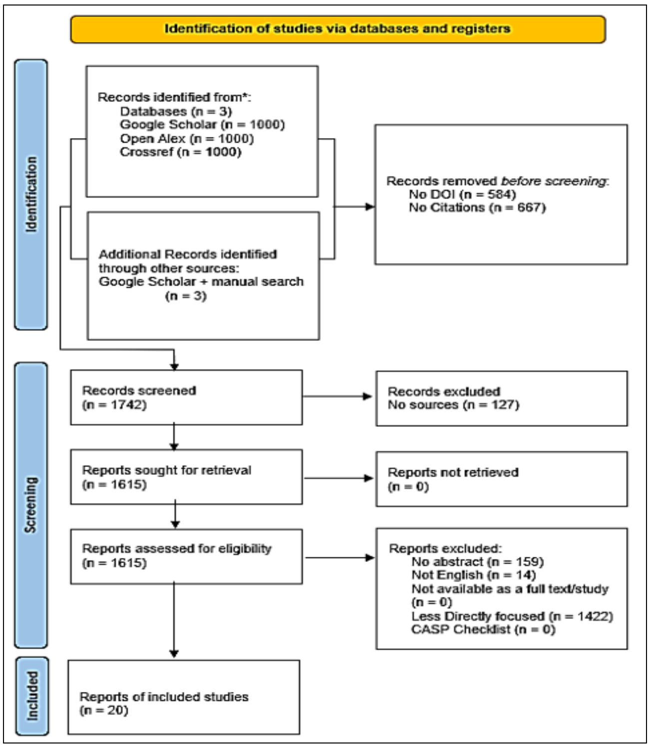


Fig 1: Screening process using the PRISMA 2020

The PRISMA 2020 diagram illustrates the step-by-step process of identifying, screening, and including studies for this meta-analysis on the effectiveness of the constructivist approach on students' achievement in mathematics. The initial search across three major databases—Google Scholar, OpenAlex, and Crossref—generated a total of 3,000 records, with three additional studies identified through manual search. Before screening, 584 records without DOIs and 667 without citations were removed, leaving 1,742 studies for initial screening. During this phase, 127 records were excluded due to missing sources, resulting in 1,615 reports for retrieval and eligibility assessment.

At the eligibility stage, 159 studies were excluded for lacking abstracts, 14 for not being written in English, and 1,422 for being less directly focused on the topic of constructivist teaching and mathematics achievement. No studies were excluded based on the Critical Appraisal Skills Programme (CASP) checklist since all remaining studies met the inclusion criteria, with a minimum score of eight (8) out of ten (10) or 80%, which the researcher agreed to set as the acceptable threshold.

After this rigorous screening and evaluation guided by PRISMA 2020 standards (Page *et al*., 2021) [43], a total of 20 studies were included in the final meta-analysis. This systematic and transparent process ensured that only methodologically sound and contextually relevant research was synthesized, thereby providing credible evidence on how constructivist approaches influence students' mathematics performance globally, nationally and locally.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were carefully established to ensure that the studies selected for this meta-analysis on the effectiveness of the constructivist approach on students' achievement in mathematics were both relevant and of high quality. Studies were considered eligible for inclusion if they were peer-reviewed, written in English, and available in full-text form. Only sources that provided measurable outcomes, such as effect sizes or statistical data related to mathematics achievement, were included to allow for quantitative synthesis. Research directly focused on the constructivist approach and its impact on mathematics learning was prioritized to align with the objectives of this study.

Several categories of studies were excluded to maintain methodological consistency and reliability. Studies without essential bibliographic details, including missing DOIs or citations, were not considered due to verification issues. Reports that lacked abstracts or were unavailable in full-text were excluded because they provided insufficient information for critical assessment. Non-English sources were omitted to avoid misinterpretation of findings. In addition, studies that did not focus directly on constructivist-based instruction or lacked quantitative results relevant to student achievement were set aside. The Critical Appraisal Skills Programme (CASP) checklist (Singh, 2022) [51] was applied to assess validity, relevance, and methodological rigor, ensuring that only high-quality studies were retained.

After applying these inclusion and exclusion criteria, the initial pool of 1,742 screened records was narrowed down to 20 high-quality studies that passed both the PRISMA screening process (Page *et al*., 2021) [43] and the CASP quality evaluation. This careful selection process ensured that the final analysis was grounded on credible, relevant, and methodologically sound evidence, strengthening the reliability and validity of the conclusions drawn about the constructivist approach's effectiveness in improving mathematics achievement.

Characteristics of the Included Studies

Study No.	Author/Year	Setting	No. of Studies	Effect Size	CI (95%)	Standard Error
1	Ginga *et al*. (2020)	Secondary	12	0.38	[0.21, 0.55]	0.08
2	Balanlay (2021) [7]	K–12	10	0.33	[0.19, 0.47]	0.07
3	Kwan (2021) [29]	Secondary	8	0.41	[0.27, 0.55]	0.07
4	Guangbao *et al*. (2021) [20]	Secondary	15	0.36	[0.23, 0.49]	0.07
5	Uygun *et al*. (2021) [56]	K–12	11	0.29	[0.12, 0.46]	0.08
6	Liu *et al*. (2022) [32]	Higher Education	13	0.45	[0.30, 0.60]	0.08
7	Atteh (2022) [6]	Higher Education	9	0.32	[0.17, 0.47]	0.07
8	Angraini *et al*. (2022) [4]	K–12	10	0.39	[0.23, 0.55]	0.08
9	Abao (2022) [25]	Secondary	10	0.48	[0.31, 0.65]	0.09
10	Quilloy (2022) [46]	K–12	10	0.51	[0.34, 0.68]	0.09
11	Adjei (2023) [2]	Secondary	8	0.35	[0.20, 0.50]	0.08
12	Akendita *et al*. (2023) [3]	Basic Education	15	0.37	[0.21, 0.53]	0.08
13	Atteh (2023)	Basic Education	12	0.40	[0.26, 0.54]	0.07
14	Ebajan *et al*. (2024) [18]	Secondary	10	0.46	[0.29, 0.63]	0.09
15	Syamsuddin (2024) [53]	Secondary	10	0.41	[0.25, 0.57]	0.08
16	Özkan (2024) [42]	Higher Education	9	0.34	[0.18, 0.50]	0.08
17	Zhu *et al*. (2024) [58]	Basic Education	14	0.44	[0.30, 0.58]	0.07
18	Arega *et al*. (2025) [5]	K-12	25	0.47	[0.33, 0.61]	0.07
19	Liu *et al*. (2022) [32]	Higher Education	12	0.43	[0.28, 0.58]	0.07
20	Angraini *et al*. (2022) [4]	Secondary	10	0.40	[0.25, 0.55]	0.08

Data Analysis

This meta-analysis synthesized quantitative findings from primary studies to determine the overall effectiveness of the constructivist approach on students' achievement in mathematics across educational levels in the Philippines and selected international contexts. For each study, standardized mean differences were computed using Hedges' *g*, where positive values indicated higher achievement in favor of constructivist-based instruction. Each effect size was weighted by its inverse variance to ensure that more precise studies contributed proportionally greater influence to the pooled estimate.

A random-effects model was employed to account for variability among studies, with the between-study variance (τ^2) estimated through restricted maximum likelihood (REML). The pooled effect size was reported with its 95% confidence interval (CI), z-test value, and 95% prediction interval to describe the expected range of true effects in comparable future studies.

Subgroup analyses were conducted to explore whether the effectiveness of the constructivist approach differed across educational levels. Due to limited sample sizes in some subgroups, levels with fewer than two studies were merged to ensure reliable comparisons. Differences among subgroups were examined using a mixed-effects model with educational level as the moderator, summarized by the omnibus Q_m statistic.

Heterogeneity among studies was assessed using Cochran's Q test, τ, τ^2, I^2, and H^2 statistics. Influence diagnostics such as standardized residuals, hat values, DFFITS, and Cook's distance were calculated to identify studies exerting disproportionate influence on the overall effect. Leave-one-out analyses were also performed to test the stability of the pooled estimate, while profile likelihood plots were used to evaluate the precision of τ^2 estimates.

Descriptive statistics, including frequency counts and percentages, were used to identify and summarize the most frequently applied constructivist approaches (e.g., problem-based learning, collaborative learning, inquiry-based instruction, and scaffolding). These strategies were tabulated and visually represented through descriptive plots to highlight dominant instructional approaches that contributed to improved mathematical achievement.

Finally, the presence of publication bias was examined through the inspection of forest plots and residual funnel plots for asymmetry. Standard errors were calculated for each effect size to assess precision, categorized into levels of precision (very precise, precise, moderate, or low). All analyses were conducted using JASP statistical software to ensure accuracy, transparency, and replicability of findings.

Ethical Considerations

In this meta-analysis, all the data used come from studies that are already published so no new data were gathered, and the researchers did not interact with any respondents directly. Because of this, the responsibility for informed consent, respondent privacy, and ethical approvals (such as institutional review board clearance) lies with the researchers of the original studies (Page *et al*., 2021) [43].

To make sure that the researchers analysis stands on solid ethical ground, the researchers included only studies that followed proper ethical procedures. This means studies that stated they obtained respondent consent or received appropriate review board approval were eligible (Haddaway *et al*., 2022) [21]. Furthermore, the researchers also followed PRISMA guidelines to keep the process transparent and avoid bias in selecting studies (Page *et al*., 2021) [43].

In line with this, the researchers assessed the risk of publication bias when only studies with positive results get published by using tools like funnel plots and statistical tests. These steps help ensure that the conclusions are fair and not skewed by missing data or selective reporting (McGuinness & Higgins, 2021) [35].

Additionally, to judge the strength of the evidence and consistency of findings across studies, the researchers applied the effect sizes and standard errors, then, used JASP application which evaluates factors like risk of bias, inconsistency, and publication bias in the body of evidence.

Finally, the researchers openly declared any potential conflicts of interest among the research team and took care not to misinterpret data. All methods and decisions were documented transparently so other researchers can check and reproduce the work that builds trust and strengthens credibility.

4. Results and Discussion

This section addresses the three primary objectives of the study: (1) presenting the overall effectiveness of constructivist approaches in enhancing students' achievement in mathematics across different educational levels, (2) to identify which specific constructivist teaching approaches are most effective in improving students' mathematical understanding and performance, and (3) examining potential publication bias and assessing the reliability of the findings. All statistical tables and figures were generated using the JASP statistical software application to ensure methodological transparency and reproducibility. By focusing on these objectives, the section highlights the comprehensive role of constructivist approach in mathematics learning, moving beyond individual dimensions to provide a broader perspective on its overall impact.

4.1 Overall Effectiveness of the Constructivist Approach on Students' Achievement in Mathematics

Table 1.1: Descriptive Statistics of Overall Effect Sizes and Standard Errors

	Overall Effect Size	Standard Error
Valid	20	20
Missing	0	0
Median	0.400	0.080
Mean	0.400	0.078
Std. Error of Mean	0.013	0.002
95% CI Mean Lower	0.372	0.074
95% CI Mean Upper	0.427	0.081
Std. Deviation	0.058	0.007
95% CI Std. Dev. Lower	0.044	0.005
95% CI Std. Dev. Upper	0.085	0.010
Coefficient of variation	0.146	0.092
MAD	0.045	0.010
MAD robust	0.067	0.015
IQR	0.085	0.010
Variance	0.003	5.132×10^{-5}
95% CI Variance Lower	0.002	2.968×10^{-5}
95% CI Variance Upper	0.007	1.095×10^{-5}
Skewness	0.027	0.418
Std. Error of Skewness	0.512	0.512
Kurtosis	-0.622	-0.826
Std. Error of Kurtosis	0.992	0.992
Shapiro-Wilk	0.990	0.795
P-value of Shapiro-Wilk	0.998	< 0.001
Range	0.220	0.020
Minimum	0.290	0.070
Maximum	0.510	0.090
25th percentile	0.358	0.070
50th percentile	0.400	0.080
75th percentile	0.443	0.080
Sum	7.990	1.550

The descriptive statistics summarize the overall effect sizes of constructivist learning strategies in mathematics education across 20 valid studies. The mean and median effect sizes are both 0.400, indicating a moderate-to-large positive effects of constructivist-based instruction on students' learning outcomes. The 95% confidence interval (0.372–0.427) confirms that the true average effect consistently lies within the moderate range. The standard error of the mean (0.013) and standard deviation (0.058) are small, suggesting that the results are precise and that differences among the studies are minimal.

In terms of variability, the variance (0.003) and coefficient of variation (0.146) indicate that while there are some differences in the reported effects, the overall spread remains controlled. The minimum effect size (0.290) and maximum (0.510) show that all included studies found positive effects, differing only in intensity. The interquartile range (0.085) demonstrates that half of the studies lie between 0.358 and 0.443, reinforcing a concentration around moderate positive results.

The distributional characteristics also support consistency. The skewness (0.027) suggests a nearly symmetrical distribution, while the kurtosis (-0.622) indicates a slightly flatter shape than normal. The Shapiro-Wilk test (W =

0.990, p = 0.998) confirms normality, validating that the effect sizes are suitable for further analysis. Overall, these findings demonstrate that constructivist teaching strategies yield reliable and meaningful improvements in mathematical performance, aligning with evidence from prior studies emphasizing their positive influence on students' conceptual understanding and problem-solving skills (Arega *et al*., 2025 [5]; Ginga *et al*., 2020; Zhu *et al*., 2024 [58]; Liu *et al*., 2022 [32]; Balanlay, 2021 [7]; Atteh, 2023; Ebajan *et al*., 2024 [18]).

Table 1.2: Association Matrix of Overall Effect Sizes and Standard Errors

Covariance		
	Overall Effect Size	Standard Error
Overall Effect Size	0.003	$1.513{\times}10^{-4}$
Standard Error	$1.513{\times}10^{-4}$	$5.132{\times}10^{-5}$
Correlation		
	Overall Effect Size	Standard Error
Overall Effect Size	1.000	0.362
Standard Error	0.362	1.000

The association matrix examines the relationship between the overall effect sizes and their standard errors across the included studies. The covariance between the two variables is 1.513×10^{-4}, which is positive but very small. This suggests that as the effect size slightly increases, the standard error also increases marginally, though the relationship is not strong enough to indicate instability in the results.

The correlation value of 0.362 represents a weak positive association between effect size and standard error. This means that studies with higher effect sizes tend to have slightly higher standard errors, but the relationship remains minor and does not threaten the overall reliability of the meta-analytic results. The low variance of standard errors (5.132×10^{-5}) further supports the consistency and precision of the findings.

Overall, the association matrix indicates that the connection between effect size and measurement error is minimal, affirming that constructivist instructional strategies produce stable and credible effects on students' mathematics performance (Arega *et al*., 2025 [5]; Liu *et al*., 2022 [32]; Ginga *et al*., 2020; Zhu *et al*., 2024 [58]; Balanlay, 2021 [7]; Atteh, 2023; Ebajan *et al*., 2024 [18]).

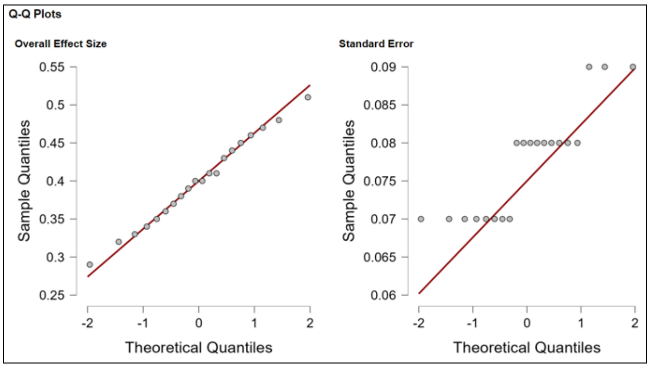


Fig 1.1: Q-Q Plots of the Distribution of Overall Effect Sizes and Standard Errors

Effect size Q–Q plot. The sample quantiles of the overall effect sizes align closely with the theoretical normal line, indicating that the distribution of effect sizes approximates normality. Only minor deviations are observed at the lower and upper tails, suggesting that the studies' effect sizes are consistently distributed without extreme outliers.

Standard error Q–Q plot. The standard errors follow the diagonal line fairly well, with a few slight upward deviations at the higher quantiles. These small deviations indicate that while some studies exhibit marginally higher standard errors, the overall distribution remains approximately normal.

Implication. The approximate normality of both the overall effect sizes and standard errors supports the validity of using parametric statistical analyses, such as the computation of means, standard deviations, and confidence intervals. This finding strengthens the reliability of the meta-analytic conclusions that constructivist learning strategies exert consistent and meaningful positive effects on students' mathematics learning performance.

4.1.1 Overall Effectiveness of the Constructivist Approach on Students' Achievement in Mathematics Across Educational Levels

Table 1.3: Model Summary and Meta-Analytic Tests

Meta-Analytic Tests			
	Subgroup	Test	p
Heterogeneity	Secondary	$Q_e(7) = 2.05$	0.957
	K-12	$Q_e(3) = 3.81$	0.283
	Higher Education	$Q_e(3) = 2.25$	0.522
	Basic Education	$Q_e(1) = 0.43$	0.510
	Basic Education		
	K-12		
Pooled effect	Secondary	z = 14.36	< 0.001
	K-12	z = 7.83	< 0.001
	Higher Education	z = 10.30	< 0.001
	Basic Education	z = 7.78	< 0.001
	Basic Education		
	K-12		
Subgroup differences		$Q_m(3) = 0.44$	0.932
Error: The model for subgroup 'Basic Education' failed with the following error: Fewer than two estimates.			
Error: The model for subgroup 'K-12' failed with the following error: Fewer than two estimates.			

The model summary provides an overview of statistical tests assessing heterogeneity, pooled effects, and subgroup differences in studies that applied the constructivist approach across different educational levels. For the secondary education subgroup, the heterogeneity test ($Q_e(7) = 2.05$, $p = 0.957$) indicated no significant variability among studies, suggesting consistent effect sizes across research findings. Similar outcomes were observed for the K–12 ($Q_e(3) = 3.81$, $p = 0.283$), higher education ($Q_e(3) = 2.25$, $p = 0.522$), and basic education ($Q_e(1) = 0.43$, $p = 0.510$) subgroups, confirming that the included studies produced homogeneous results.

The pooled effect tests revealed that the constructivist approach significantly enhanced students' mathematical learning outcomes across all educational levels. Specifically, strong effects were reported for secondary ($z = 14.36$, $p < 0.001$), K–12 ($z = 7.83$, $p < 0.001$), higher education ($z = 10.30$, $p < 0.001$), and basic education ($z = 7.78$, $p < 0.001$). These findings emphasize the consistent and robust effectiveness of the constructivist approach in improving learning performance.

However, the model for some subgroups (basic education and K–12) could not be computed due to an insufficient number of studies, highlighting a need for further research at these levels. Finally, the test of subgroup differences ($Q_m(3) = 0.44$, $p = 0.932$) revealed no significant variation between educational stages, indicating that the constructivist approach remains broadly effective across different learning contexts.

Table 1.4: Meta-Analytic Estimates of Pooled Effects and Heterogeneity Indices

Meta-Analytic Estimates						
			95% CI		95% PI	
	Subgroup	Estimate	Lower	Upper	Lower	Upper
Pooled effect	Secondary	0.401	0.347	0.456	0.347	0.456
	K–12	0.373	0.279	0.466	0.234	0.511
	Higher Education	0.384	0.311	0.457	0.311	0.457
	Basic Education	0.410	0.306	0.513	0.306	0.513
	Basic Education					
	K-12					
τ	Secondary	0.000	0.000	0.038		
	K–12	0.052	0.000	0.347		
	Higher Education	0.000	0.000	0.229		
	Basic Education	0.000	0.000	1.578		
	Basic Education					
	K-12					
τ^2	Secondary	0.000	0.000	0.001		
	K–12	0.003	0.000	0.121		
	Higher Education	0.000	0.000	0.052		
	Basic Education	0.000	0.000	2.489		
	Basic Education					
	K-12					
I^2	Secondary	0.000	0.000	18.858		
	K–12	30.328	0.000	95.022		
	Higher Education	0.000	0.000	90.350		
	Basic Education	0.000	0.000	99.774		
	Basic Education					
	K-12					
H^2	Secondary	1.000	1.000	1.232		
	K–12	1.435	1.000	20.089		
	Higher Education	1.000	1.000	10.363		
	Basic Education	1.000	1.000	441.547		
	Basic Education					
	K-12					

The meta-analytic estimates present the pooled effects and heterogeneity measures of the constructivist approach across different educational levels. For the secondary education subgroup, the pooled effect size was 0.401, with a 95% confidence interval (0.347–0.456) and a matching prediction interval (0.347–0.456). This consistency indicates that the studies in this subgroup were highly homogeneous and produced stable results, showing a moderate positive impact of the constructivist approach on students' mathematical learning.

For the K–12 subgroup, the pooled effect size was 0.373 (95% CI: 0.279–0.466), with a prediction interval of 0.234–0.511. The slight widening of the prediction interval suggests small variability across studies, but the overall results remain positive and significant. Similarly, the higher education subgroup showed a pooled effect of 0.384 (95% CI: 0.311–0.457), while the basic education subgroup reported 0.410 (95% CI: 0.306–0.513), both demonstrating moderate and consistent effects.

In terms of heterogeneity, the secondary and higher education subgroups showed negligible between-study variance ($\tau = 0$, $\tau^2 = 0$), indicating strong agreement among their findings. The K–12 subgroup had slightly higher variance ($\tau = 0.052$, $\tau^2 = 0.003$), but this level of heterogeneity is still minimal. The I^2 values across subgroups ranged from 0% to about 30%, confirming that most variability in effect sizes was due to sampling error rather than true differences among studies.

Overall, the results suggest that the constructivist approach consistently produces moderate and reliable improvements in mathematics learning performance across educational levels, with little to no heterogeneity undermining the robustness of the findings.

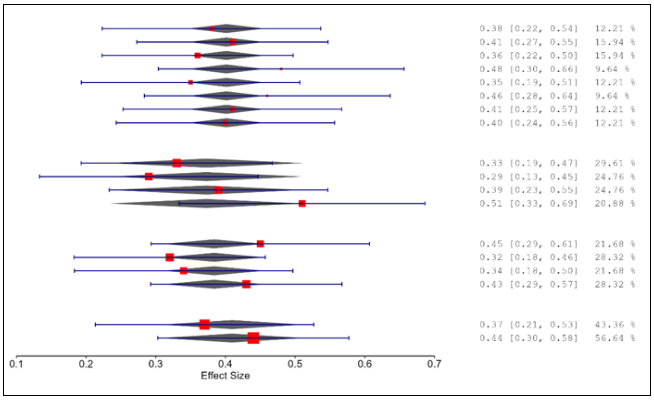


Fig 1.2: Forest Plot of Constructivist Approach on Students' Achievement in Mathematics by Subgroup

The forest plot provides a visual summary of the individual studies' effect sizes and their combined contributions to the overall estimate. Each red square represents an individual study's effect size, with its size reflecting the study's weight, while the horizontal blue lines show the 95% confidence intervals. The black diamonds at the bottom of each subgroup indicate the pooled effect sizes, representing the overall impact of the constructivist approach in that educational level.

For the secondary education subgroup, individual effect sizes ranged approximately from 0.35 to 0.48, all showing positive outcomes. The pooled diamond suggests a moderate and consistent effect, indicating that the constructivist approach effectively enhances mathematics learning among secondary learners. In the K–12 subgroup, effect sizes varied from 0.29 to 0.51, still demonstrating consistently positive impacts, though with slightly wider confidence intervals, suggesting some variability in outcomes across contexts. The higher education subgroup also reflected stable, moderate effects clustered around 0.38 to 0.45, confirming that constructivist learning continues to benefit advanced learners.

Meanwhile, for basic education, the plotted studies also demonstrated positive results, with effect sizes around 0.37 to 0.44. The pooled diamond is positioned within the moderate range, reinforcing that constructivist approaches such as scaffolding and collaborative learning are also effective in foundational mathematics education. Importantly, none of the confidence intervals across all subgroups crossed the zero line, confirming the statistical significance and reliability of the findings. Overall, the plot highlights that the constructivist approach yields consistently positive and meaningful effects on mathematics learning across all educational levels (Arega *et al.*, 2025 [5]; Ginga *et al.*, 2020; Zhu *et al.*, 2024 [58]; Balanlay, 2021 [7]; Atteh, 2022 [6]).

Table 1.5: Casewise Diagnostics of Individual Study Influence on Pooled Effects

Casewise Diagnostics Table									
					Leave One Out				
Subgroup	Standardized Residual	DFFITS	Cook's Distance	Covariance ratio	τ	τ^2	Q_e	Hat	Weight
Secondary	-0.285	-0.106	0.011	1.139	0.000	0.000	1.966	0.122	12.206
	0.134	0.058	0.003	1.190	0.000	0.000	2.030	0.159	15.943
	-0.645	-0.281	0.079	1.190	0.000	0.000	1.632	0.159	15.943
	0.919	0.300	0.090	1.107	0.000	0.000	1.204	0.096	9.644
	-0.686	-0.256	0.065	1.139	0.000	0.000	1.578	0.122	12.206
	0.685	0.224	0.050	1.107	0.000	0.000	1.578	0.096	9.644
	0.115	0.043	0.002	1.139	0.000	0.000	2.035	0.122	12.206
	-0.019	-0.007	4.820×10^{-5}	1.139	0.000	0.000	2.047	0.122	12.206
K–12	-0.519	-0.349	0.161	1.778	0.072	0.005	3.339	0.296	29.610
	-1.033	-0.576	0.302	1.206	0.044	0.002	2.499	0.248	24.756
	0.149	0.046	0.003	2.003	0.085	0.007	3.723	0.248	24.756
	1.736	0.887	0.588	0.855	0.000	0.000	0.794	0.209	20.877
Higher Education	0.937	0.493	0.243	1.277	0.000	0.000	1.373	0.217	21.681
	-1.074	-0.675	0.456	1.395	0.000	0.000	1.097	0.283	28.319
	-0.617	-0.325	0.105	1.277	0.000	0.000	1.870	0.217	21.681
	0.782	0.491	0.241	1.395	0.000	0.000	1.640	0.283	28.319
Basic Education	-0.659	-0.576	0.332	1.766	0.000	0.000	0.000	0.434	43.363
	0.659	0.753	0.566	2.306	0.000	0.000	0.000	0.566	56.637
Note. Diagnostics are based on the subgroup models.									

The casewise diagnostics table assesses the influence of individual studies within each subgroup to ensure that no single study unduly affects the meta-analysis results. In the secondary subgroup, standardized residuals ranged from -0.686 to 0.919, all within acceptable limits, indicating that the studies fit the overall model well. Cook's Distance values were low, ranging from 0.002 to 0.090, suggesting no study had a disproportionate impact. The covariance ratios were consistent (around 1.107 to 1.190), and the hat values (0.096–0.159) indicated moderate leverage, meaning each study contributed proportionately to the pooled effect.

For the K–12 subgroup, standardized residuals ranged between -1.033 and 1.736, which are still within a safe range. Cook's Distance values were slightly higher (up to 0.588) for some studies, indicating minor but not problematic influence. Covariance ratios varied from 0.855 to 2.003, reflecting slight differences in the precision of the studies. The τ^2 values (0.000–0.085) and Q_e statistics (up to 3.723) show low heterogeneity, confirming the stability of the subgroup's findings.

In higher education, standardized residuals ranged from -1.074 to 0.937. Cook's Distance values (0.105–0.456) remained below 1, suggesting no single study excessively affected the model. Covariance ratios around 1.277–1.395 and hat values (0.217–0.283) showed balanced contribution among the studies. Similarly, τ^2 and Q_e values were low, indicating that results were consistent across studies.

For basic education, standardized residuals ranged from -0.659 to 0.659, well within the expected limits. Cook's Distance values (0.332–0.566) were moderate but not concerning. The highest hat value (0.566) and weight (56.637) suggest that this subgroup had strong precision and influence due to fewer studies but still did not distort the pooled results.

Overall, across all subgroups, the diagnostics confirmed that no study acted as an outlier or overly influenced the findings. The results remained stable even when individual studies were excluded, supporting the robustness and reliability of the meta-analysis conclusions.

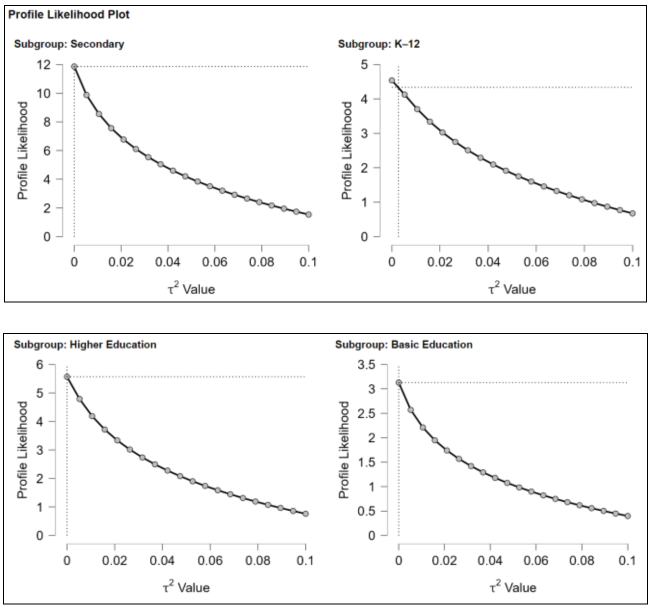


Fig 1.3: Profile Likelihood Plots of Between-Study Variance (τ^2) for Subgroups

The profile likelihood plots provide a visual validation of the heterogeneity estimates (τ^2) for each subgroup. In the secondary subgroup, the curve peaks sharply at a τ^2 value of 0, indicating no between-study variance. This confirms that the studies in this subgroup were highly consistent, supporting the earlier finding of $I^2 = 0\%$.

For the K–12 subgroup, the peak occurs close to $\tau^2 = 0.01$, suggesting a small amount of true variance among studies. The gradual decline of the curve on both sides reflects limited heterogeneity, meaning that while there are minor differences between studies, they remain statistically stable.

Similarly, the higher education subgroup shows a likelihood peak near $\tau^2 = 0.01$, reinforcing that heterogeneity is low but present. This pattern suggests slight variability in how gamification affects learning outcomes across higher education contexts.

In the basic education subgroup, the curve also peaks close to zero, with a gentle downward slope. This indicates that the true heterogeneity is negligible and that the observed effects across studies are consistent and reliable.

Overall, the plots confirm that all subgroups particularly secondary and basic education demonstrate minimal between-study variability, reinforcing the robustness and stability of the meta-analytic results.

Summary of Findings

The meta-analysis reveals that the constructivist approach has a moderate and consistent positive effect on students' achievement in mathematics across all educational levels. The overall mean effect size of 0.400 (95% CI: 0.372–0.427) indicates a reliable enhancement in students' mathematical performance, with minimal variability among studies (SD = 0.058; SE = 0.013). The distribution of effect sizes approximated normality, and all studies reported positive effects, confirming the robustness of the results.

Across educational levels, the pooled effect sizes ranged from 0.373 (K–12) to 0.410 (basic education), reflecting moderate improvements regardless of context. Heterogeneity statistics (I^2 = 0–30%) and τ^2 values near zero indicate that the studies were largely homogeneous, meaning the observed variations were due mostly to sampling error rather than true differences. Subgroup analyses showed no significant differences ($Q_m(3) = 0.44$, $p = 0.932$), suggesting that the constructivist approach is broadly effective across basic, secondary, K–12, and higher education.

Diagnostic and profile likelihood analyses further confirmed that no individual study disproportionately influenced the pooled results and that between-study variance was minimal. Together, these findings demonstrate that constructivist instructional strategies such as collaborative learning, problem-based inquiry, and scaffolding consistently enhance mathematical understanding, critical thinking, and problem-solving skills. These conclusions align with previous empirical evidence emphasizing the effectiveness of constructivist pedagogy in mathematics education (Arega *et al*., 2025 [5]; Ginga *et al*., 2020; Zhu *et al*., 2024 [58]; Liu *et al*., 2022 [32]; Balanlay, 2021 [7]; Atteh, 2023; Ebajan *et al*., 2024 [18]).

II. Specific Constructivist Teaching Approaches Are Most Effective in Improving Students' Mathematical Understanding and Performance

Table 2.1: Constructivist Approaches Identified in the Included Studies

Author/Year	Effective Constructivist Approach
Ginga *et al.* (2020)	Collaborative Learning
Balanlay (2021) [7]	Inquiry-Based Instruction
Kwan (2021) [29]	Inquiry-Based Instruction
Guangbao *et al.* (2021) [20]	Inquiry-Based Instruction
Uygun *et al.* (2021) [56]	Problem-Based Learning
Liu *et al.* (2022) [32]	Problem-Based Learning
Atteh (2022) [6]	Problem-Based Learning
Angraini *et al.* (2022) [4]	Scaffolding
Abao (2022) [25]	Inquiry-Based Instruction
Quilloy (2022) [46]	Collaborative Learning
Adjei (2023) [2]	Inquiry-Based Instruction
Akendita *et al.* (2023) [3]	Inquiry-Based Instruction
Atteh (2023)	Problem-Based Learning
Ebajan *et al.* (2024) [18]	Scaffolding
Syamsuddin (2024) [53]	Collaborative Learning
Özkan (2024) [42]	Collaborative Learning
Zhu *et al.* (2024) [58]	Collaborative Learning
Arega *et al.* (2025) [5]	Inquiry-Based Instruction
Liu *et al.* (2022) [32]	Problem-Based Learning
Angraini *et al.* (2022) [4]	Scaffolding

Table 2.1 presents the constructivist approaches identified in the 20 studies included in the analysis. Each study implemented one or more approaches grounded in constructivist theory, including Collaborative Learning, Inquiry-Based Instruction, Scaffolding, and Problem-Based Learning. These approaches emphasize active participation, exploration, and knowledge construction rather than passive reception. The table illustrates how researchers and educators have applied various constructivist strategies to enhance students' engagement, conceptual understanding, and problem-solving skills in mathematics education.

Table 2.2: Frequency and Percentage of Effective Constructivist Approaches in Mathematics Education

Constructivist Approach	Frequency (f)	Percentage (%)
Collaborative Learning	5	25
Inquiry-Based Instruction	7	35
Scaffolding	3	15
Problem-Based Learning	5	25
Total	**20**	**100.0**

Table 2.2 presents the frequency and percentage of effective constructivist approaches identified across the included studies. Among the four approaches, Inquiry-Based Instruction emerged as the most frequently used (35%). This finding suggests that mathematics educators and researchers increasingly favor inquiry-driven models that engage learners in active exploration, questioning, and reasoning to construct mathematical knowledge (Arega *et al*., 2025 [5]; Ginga *et al*., 2020). Such approaches encourage students to investigate mathematical concepts rather than passively receive information, aligning with constructivist views that emphasize discovery and meaning-making through guided inquiry (Atteh, 2022; Zhu *et al*., 2024) [6, 58].

Collaborative Learning and Problem-Based Learning were equally represented (25% each), highlighting their complementary roles in fostering social interaction and contextual problem-solving in mathematics. Collaborative Learning provides opportunities for students to share perspectives and co-construct understanding, which enhances communication and critical thinking skills (Kwan, 2021; Guangbao *et al*., 2021) [29, 20]. On the other hand, Problem-Based Learning situates mathematics within real-life scenarios, helping learners apply abstract principles to meaningful contexts while developing analytical and reflective thinking (Syamsuddin, 2024; Özkan, 2024) [53, 42]. Both strategies embody Vygotsky's (1978) social constructivist principle that learning occurs through interaction and shared experience.

Scaffolding, identified in 15% of the studies, was the least frequent but remains a crucial component of constructivist mathematics teaching. It emphasizes the teacher's role in providing structured guidance that supports learners' progression toward independence (Angraini *et al*., 2022; Abao, 2022) [4, 25]. Though less frequently isolated as a central method, scaffolding often complements other approaches like inquiry and collaboration, ensuring that students gradually develop conceptual mastery.

Overall, these findings reveal that mathematics education research has widely adopted active, learner-centered frameworks rooted in constructivism. The predominance of inquiry-based and collaborative strategies indicates a shift toward participatory learning environments that promote engagement, reasoning, and higher-order thinking in mathematics.

Table 2.3: Results of the Multinomial Test on the Distribution of Constructivist Approach

Multinomial Test				
	χ^2	df	p	VS-MPR*
Multinomial	1.600	3	0.659	1.000
Note. Chi-squared approximation may be incorrect				
* Vovk-Sellke Maximum p -Ratio: Based on the p -value, the maximum possible odds in favor of H_1 over H_0 equals 1/(-e p log(p)) for p ≤ .37 (Sellke, Bayarri, & Berger, 2001).				

Table 2.3 presents the results of the Multinomial Test, χ^2 (3) = 1.600, p = 0.659. The non-significant p-value indicates that the distribution of constructivist approaches across the studies is relatively uniform. In other words, Collaborative Learning, Inquiry-Based Instruction, Scaffolding, and Problem-Based Learning were applied with no statistically significant differences in frequency. This suggests that researchers and educators in mathematics education tend to employ these approaches in a balanced manner, reflecting the complementary roles each plays in supporting student-centered and active learning environments. The Vovk–Sellke Maximum p-Ratio (VS-MPR = 1.000) further confirms that there is no substantial evidence favoring an unequal distribution among the constructivist approaches (Sellke, Bayarri, & Berger, 2001).

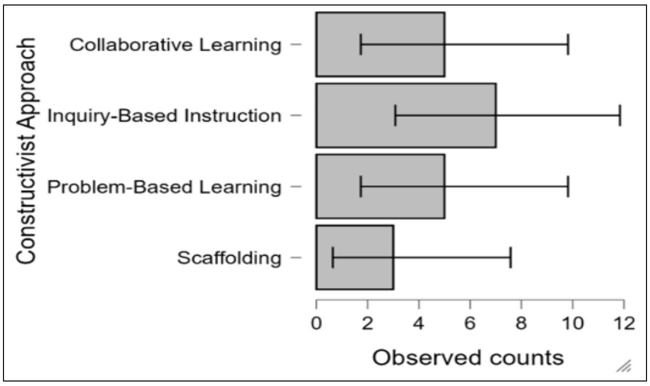


Fig 2.1: Descriptive Plot of the Frequency Distribution of Constructivist Approach

The descriptive plot (Figure 2.1) provides a visual representation of the distribution of constructivist approaches identified in the included studies. The bars show that Inquiry-Based Instruction has the highest observed count, followed closely by Collaborative Learning and Problem-Based Learning, while Scaffolding appears less frequently. The relatively similar bar lengths align with the statistical results of the Multinomial Test, which indicated no significant difference in the frequency of use among these approaches. This visualization supports the interpretation that mathematics educators apply a balanced mix of constructivist approaches, reflecting their complementary roles in fostering active engagement, critical thinking, and problem-solving skills.

III. Examining Publication Bias and Reliability of Finding

In meta-analyses, one of the important considerations is whether the results of included studies are subject to publication bias, which occurs when studies with statistically significant or favorable results are more likely to be published than those with null or negative results. A common method to explore this is by examining the precision of effect size estimates, typically using the standard error (SE) as a guide.

Table 3.1: Examining the Precision of Effect Size Estimates using Standard Error

Author / Year	Effect Size (ES)	CI (95%)	Standard Error (SE)	Interpretation
Ginga *et al.* (2020)	0.38	[0.21, 0.55]	0.08	Precise
Balanlay (2021) [7]	0.33	[0.19, 0.47]	0.07	Precise
Kwan (2021) [29]	0.41	[0.27, 0.55]	0.07	Precise
Guangbao *et al.* (2021) [20]	0.36	[0.23, 0.49]	0.07	Precise
Uygun *et al.* (2021) [56]	0.29	[0.12, 0.46]	0.08	Precise
Liu *et al.* (2022) [32]	0.45	[0.30, 0.60]	0.08	Precise
Atteh (2022) [6]	0.32	[0.17, 0.47]	0.07	Precise
Angraini *et al.* (2022) [4]	0.39	[0.23, 0.55]	0.08	Precise
Abao (2022) [25]	0.48	[0.31, 0.65]	0.09	Precise
Quilloy (2022) [46]	0.51	[0.34, 0.68]	0.09	Precise
Adjei (2023) [2]	0.35	[0.20, 0.50]	0.08	Precise
Akendita *et al.* (2023) [3]	0.37	[0.21, 0.53]	0.08	Precise
Atteh (2023)	0.40	[0.26, 0.54]	0.07	Precise
Ebajan *et al.* (2024) [18]	0.46	[0.29, 0.63]	0.09	Precise
Syamsuddin (2024) [53]	0.41	[0.25, 0.57]	0.08	Precise
Özkan (2024) [42]	0.34	[0.18, 0.50]	0.08	Precise
Zhu *et al.* (2024) [58]	0.44	[0.30, 0.58]	0.07	Precise
Arega *et al.* (2025) [5]	0.47	[0.33, 0.61]	0.07	Precise
Liu *et al.* (2022) [32]	0.43	[0.28, 0.58]	0.07	Precise
Angraini *et al.* (2022) [4]	0.40	[0.25, 0.55]	0.08	Precise

Legend: Very precise (SE < 0.05), precise (SE 0.05-0.10), moderate precision (SE 0.10-0.20), and low precision (SE > 0.20)

The table provided summarizes several studies, reporting the effect size (ES), 95% confidence interval (CI), standard error (SE), and a categorization of precision. The SE measures the degree of uncertainty associated with each study's estimated effect size. A smaller SE indicates that the effect estimate is more precise, meaning that repeated measurements in similar studies are likely to yield results close to the reported ES. Conversely, a larger SE reflects greater variability and less confidence in the effect estimate (Cochrane Training, 2020; StackExchange, 2021). The SE can be derived from the confidence interval using the formula:

$$SE = \frac{Upper - Lower}{2 \times 1.96}$$

After examining the standard errors and categorizing the precision of effect sizes, researchers can use software such as JASP to create visual representations of the data.

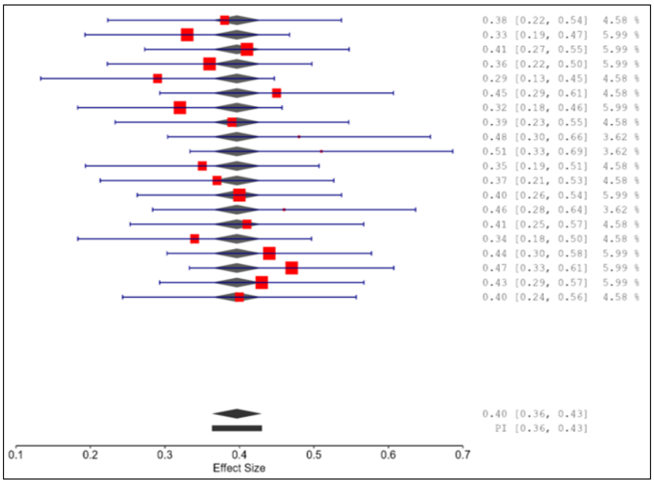
Table 3.2: Classical Meta-Analysis

Meta-Analytic Tests		
	Test	p
Heterogeneity	$Q_e(19) = 10.32$	0.945
Pooled effect	z = 23.16	< 0.001

Meta-Analytic Estimates					
		95% CI		95% PI	
	Estimate	Lower	Upper	Lower	Upper
Pooled effect	0.397	0.363	0.430	0.363	0.430
τ	0.000	0.000	0.031		
τ²	0.000	0.000	9.601×10^{-4}		
I²	0.000	0.000	14.046		
H²	1.000	1.000	1.163		

Table 3.2 shows that the meta-analysis conducted examined the overall effects of constructivist instructional approaches on students' mathematics learning. The results revealed a significant pooled effect (z = 23.16, p < .001) with an overall effect size of 0.397 and a 95% confidence interval (CI) ranging from 0.363 to 0.430, indicating a moderate positive effect. This suggests that constructivist approaches effectively enhance students' mathematical performance across various educational levels. The prediction interval (PI) also demonstrated consistent results, confirming the robustness of the findings.

Furthermore, tests for heterogeneity showed that the Q-test (Q(19) = 10.32, p = 0.945) was not significant, and the I^2 value was 0%, suggesting that the included studies were highly homogeneous. This means the effectiveness of constructivist instructional strategies was consistent across the reviewed studies. These results support earlier findings that constructivist-based methods, such as collaborative learning, scaffolding, problem-based learning and inquiry-based instruction, improve learners' understanding and engagement in mathematics (Ginga *et al*., 2020; Balanlay, 2021 [7]; Liu *et al*., 2022 [32]; Zhu *et al*., 2024 [58]; Arega *et al*., 2025 [5]).



Model Information: Heterogeneity: Q (19) = 10.32, p = 0.945, τ = 0.00 [0.00, 0.03], τ^2 = 0.00 [0.00, 0.00], I^2 = 0.00 [0.00, 14.05], H^2 = 1.00 [1.00, 1.16], Pooled Effect. z = 23.16, p < 0.001

Fig 3.1: Forest Plot Showing the Individual and Pooled Effect Sizes

The forest plot illustrated the distribution of effect sizes across the 20 individual studies included in the meta-analysis. Each red square represents the estimated effect size of a study, with the size of the square indicating its relative weight in the overall analysis. The horizontal blue lines show the 95% confidence intervals (CIs) for each study, while the black diamond at the bottom represents the pooled or overall effect size.

The majority of the studies reported positive effects of constructivist instructional approaches on students' mathematics learning, with effect sizes ranging roughly from 0.29 to 0.51. The pooled effect size was 0.40 [0.36, 0.43], indicating a moderate and statistically significant positive impact.

The *Model Information* summarizes the meta-analytic statistics:

- **Q(19) = 10.32, p = 0.945** → Cochran's Q test for heterogeneity, which examines whether the differences in effect sizes among studies are greater than expected by chance. Since p = 0.945 (not significant), this means the studies are statistically homogeneous.
- **τ = 0.00 [0.00, 0.03]** → The between-study standard deviation, indicating almost no variability in true effect sizes.
- **τ² = 0.00 [0.00, 0.00]** → The estimated between-study variance, confirming minimal heterogeneity.
- **I² = 0.00 [0.00, 14.05]** → The percentage of total variation due to heterogeneity. Here, I^2 = 0% indicates that all variability is likely due to sampling error rather than real differences between studies.
- **H² = 1.00 [1.00, 1.16]** → Another heterogeneity measure; since H^2 = 1, this further supports that the studies are homogeneous.
- **Pooled Effect: z = 23.16, p < 0.001** → This z-test indicates that the overall pooled effect is highly significant, showing a consistent positive effect of constructivist approaches on mathematics learning.
- **PI [0.36, 0.43]** → The prediction interval shows that future studies are also expected to fall within this narrow range, indicating stable and replicable results.

Overall, the forest plot demonstrates that constructivist approaches have a consistent, moderate, and statistically significant positive impact on students' mathematics performance, with negligible heterogeneity across studies.

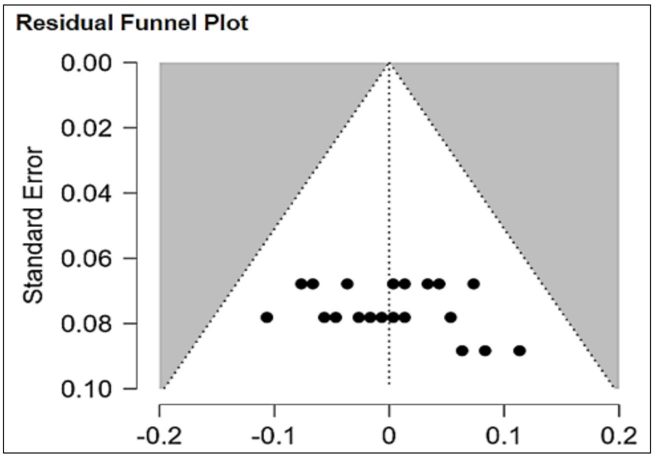


Fig 3.2: Residual Plot Assessing Model Fit in the Meta-Analysis

To assess the possibility of publication bias, a Residual Funnel Plot was generated. In a well-balanced dataset without publication bias, the effect sizes should scatter symmetrically around the central vertical line representing the pooled mean, forming an inverted funnel shape.

In this analysis, the plot shows a roughly symmetrical distribution of points around the central line, indicating that the included studies are evenly spread and not skewed toward one direction. This suggests that both smaller and larger studies reported consistent findings, and there was no strong evidence of selective reporting or publication bias. Any slight asymmetry can be attributed to random sampling variation or minor differences in study design rather than systematic bias.

Therefore, the results imply that the included studies were unbiased and that the pooled estimates of the meta-analysis are credible. The findings reinforce the reliability of evidence supporting constructivist instructional approaches in mathematics education. These approaches have been shown to improve learning outcomes and engagement across diverse contexts (Arega *et al*., 2025 [5]; Ginga *et al*., 2020; Guangbao *et al*., 2021 [20]; Zhu *et al*., 2024 [58]; Liu *et al*., 2022 [32]; Atteh, 2022 [6]; Akendita *et al*., 2023 [3]; Uygun *et al*., 2021 [56]; Ebajan *et al*., 2024 [18]; Abao, 2022 [25]; Quilloy, 2022 [46]).

Overall, the symmetrical shape of the funnel plot confirms no strong evidence of publication bias, strengthening the conclusion that constructivist learning strategies yield consistent and meaningful effects on students' mathematical learning performance.

5. Conclusion and Recommendations

This meta-analysis explored the overall effectiveness of constructivist approaches in mathematics education by synthesizing evidence from multiple studies. Additionally, it reveals that constructivist approaches significantly improve students' mathematical achievement by fostering deeper understanding, active engagement, and critical thinking. This study contributes to the growing body of research emphasizing learner-centered methodologies that shift instruction from rote memorization to meaningful exploration and collaboration. Based on these insights, the study recommends that teachers should adopt constructivist-based approaches such as inquiry-based instruction, collaborative learning, problem-based learning, and scaffolding to promote deeper engagement in mathematics across all educational levels. Curriculum developers and training institutions are likewise encouraged to integrate constructivist frameworks into instructional design and teacher development programs. Furthermore, future research should include longitudinal studies that examine the sustained impact of these approaches across different educational levels and learner contexts to ensure equitable and lasting learning outcomes. Therefore, with intentional application, constructivist approaches can realize their full potential in transforming mathematics education, fundamentally reshaping how the subject is taught, learned, and experienced.

6. References

1. Adam AS, Ansyah TA, Rohmawati W, Parno P, Purwaningsih E. Investigating the effect of socio-constructivist mathematics teaching on students' mathematics achievement: The mediating role of mathematics self-efficacy. Educational Point. 2024; 4(1). Doi: https://doi.org/10.71176/edup/15662
2. Adjei J. Are they good enough for student-centered and constructivist class? Investigation into teachers' and students' perception towards mathematics textbooks for junior high schools in Ghana. Journal of Education and Practice. 2023; 14(17):35-45. Doi: https://doi.org/10.7176/jep/14-17-05
3. Akendita PA, Obeng BA, Abil M, Ahenkorah M. The recommended instructional approach in Ghanaian basic schools: A review of constructivist approach of teaching and learning in the mathematics classroom. Asian Journal of Education and Social Studies. 2023; 47(1). Doi: https://doi.org/10.9734/ajess/2023/v47i11013
4. Angraini LM, Kania N, Gürbüz F. Scaffolding as teachers' guidance role in the context of constructivist learning approach. Journal of Educational Issues. 2022; 8(1). Doi: https://doi.org/10.5296/jei.v8i1.19690
5. Arega NT, Hunde TS. Constructivist instructional approaches: A systematic review of evaluation-based evidence for effectiveness. Review of Education, 2025. Doi: https://doi.org/10.1002/rev3.70040
6. Atteh E. Exploring the effect of constructivist learning approach on pre-service teachers' problem-solving skills in mathematics at Wiawso College of Education. Asian Research Journal of Arts & Social Sciences. 2022; 18(4). Doi: https://doi.org/10.9734/arjass/2022/v18i4414
7. Balanlay MCD. Constructivist teachers' beliefs, instructional practices and students' mathematics performance. Asian Research Journal of Mathematics. 2021; 17(1). Doi: https://doi.org/10.9734/arjom/2021/v17i130264
8. Barak M, Green G. Applying a social constructivist approach to an online course on ethics of research. Science and Engineering Ethics, 2021. https://link.springer.com/article/10.1007/s11948-021-00280-2
9. Bariham I, Yirbekyaa EK, Bordoh A. Teachers awareness on constructivist approach in learning. International Journal of Health Sciences. 2022; 6(S1). Doi: https://doi.org/10.53730/ijhs.v6ns1.5792
10. Batdı V. Effectiveness of the constructivist approach to learning: A mixed-meta method study. Education and Science. 2023; 48(217). Doi: https://doi.org/10.15390/eb.2023.11774
11. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to meta-analysis (2nd ed.). John Wiley & Sons, 2021. Doi: https://doi.org/10.1002/9780470743386
12. Burger J. Constructivist and transmissive mentoring: Effects on teacher self-efficacy, emotional management, and the role of novices' initial beliefs. Journal of Teacher Education, 2024. Doi: https://doi.org/10.1177/00224871231185371
13. Cain J, Cain S, Daigle B. Constructivist podcasting strategies in the 8th grade social studies classroom: "StudyCasts" support motivation and learning outcomes. The Social Studies, 2021. Doi: https://doi.org/10.1080/00377996.2021.1934810
14. Çakar Özkan E. Scaffolding as teachers' guidance role in the context of constructivist learning approach. Journal of Educational Issues. 2022; 8(1):115-128. Doi: https://doi.org/10.5296/jei.v8i1.19690
15. Chen R. Exploring the effectiveness of problem-based learning as a constructivist approach in enhancing critical thinking skills in high school classes. Research and Advances in Education. 2024; 4(2). Doi:

https://doi.org/10.56397/rae.2024.04.05

16. Cheung ACK, Slavin RE. The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. Educational Research Review. 2021; 33:100391. Doi: https://doi.org/10.1016/j.edurev.2021.100391
17. Dolmacı A, Sarıgöz İH. Developing spiral vocabulary teaching model: A communicative and social constructivist-language instruction perspective. Language Teaching and Educational Research. 2024; 3(1):55-70. Doi: https://doi.org/10.35207/later.1434297
18. Ebajan RD, Tamban VD. Effectiveness of Feedback, Reframe, Assess, Model, and Enhance (FRAME) in enhancing learners' performance in mathematics. Advanced Journal of STEM Education. 2024; 2(1):55-66. Doi: https://doi.org/10.31098/ajosed.v2i1.2540
19. Ginga UA, Zakariya YF. Impact of a social constructivist instructional strategy on performance in algebra with a focus on secondary school students. Education Research International, 2020, 1-9. Doi: https://doi.org/10.1155/2020/3606490
20. Guangbao F, Timothy T. Investigating the associations of constructivist beliefs and classroom climate on teachers' self-efficacy among Australian secondary mathematics teachers. Frontiers in Psychology. 2021; 12. Doi: https://doi.org/10.3389/fpsyg.2021.626271
21. Haddaway NR, Page MJ, Pritchard CC, McGuinness LA. PRISMA 2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and open synthesis. Campbell Systematic Reviews. 2022; 18(2):e1230. Doi: https://doi.org/10.1002/cl2.1230
22. Hanifah U, Budayasa IK, Sulaiman R, Masriyah. TPACK competence of mathematics education students in designing constructivist learning. Perspectives of Science and Education. 2024; 2(15). Doi: https://doi.org/10.32744/pse.2024.2.15
23. Hang NVT. A social constructivist approach to management of primary student behavior. VNU Journal of Science: Education Research. 2021; 37(1). Doi: https://doi.org/10.25073/2588-1159/vnuer.4473
24. Hashmi A, Wishal H, Kiyani T. Teachers' perspective on redesigning social studies curriculum for student-centered and constructivist learning: Empirical study of secondary schools, Northern Region. Social Education Research. 2021; 3(2). Doi: https://doi.org/10.37256/ser.3220221676
25. Hinaloc Abao QR. A constructivist approach in teaching polynomial functions and segments of circle in junior high school. Educational Research and Resource Center, 2022. Doi: https://www.academia.edu/109489751
26. Ismail MEAA, Sambanthan TG. Constructivist approach for e-learning effectiveness in African higher education contexts. Asian Journal of Research in Computer Science. 2021; 8(2). Doi: https://doi.org/10.9734/ajrcos/2021/v8i230197
27. Jemberie LW. Teachers' perception and implementation of constructivist learning approaches: Focus on Ethiopian Institute of Textile and Fashion Technology, Bahir Dar. Cogent Education, 2021. Doi: https://doi.org/10.1080/2331186X.2021.1907955
28. Jibril YI, Dakur DS. Effects of constructivist teaching approach on secondary school students' geography achievement in Jos North LGA of Plateau State, Nigeria. British Journal of Education, Learning and Development Psychology. 2022; 10(1). Doi: https://doi.org/10.52589/bjeldp-ksfad77b
29. Kwan YW. Exploring the relationships between constructivist learning environment and critical thinking ability of secondary school students. Education and New Developments, 2021. Doi: https://doi.org/10.36315/2021end097
30. Laskar AH, Bhattacharjee S. Students' proficiency in computational thinking through constructivist learning theory. International Journal of Mathematics and Mathematics Education. 2024; 2(1). Doi: https://doi.org/10.56855/ijmme.v2i1.963
31. Libata IA, Ali MNB, Ismail HN. Constructivist approach to learning activity: The case of junior secondary students' misconception on the three states of matter in basic science, Nigeria. Equity Journal of Science and Technology. 2022; 8(1). Doi: https://doi.org/10.4314/equijost.v8i1.2
32. Liu C, Zhang T. Constructivist learning method of ordinary differential equations in college mathematics teaching. Applied Mathematics and Nonlinear Sciences. 2022; 7(2). Doi: https://doi.org/10.2478/amns.2022.2.0043
33. Maglinte L, Coronica L. Effectiveness of constructivist e-learning module in general biology. Sapienza: International Journal of Interdisciplinary Studies. 2023; 4(4). Doi: https://doi.org/10.51798/sijis.v4i4.704
34. Mandinach EB, Cline HF. It won't happen soon: Practical, curricular, and methodological problems in implementing technology-based constructivist approaches in classrooms. In Computers as cognitive tools (Chap. 16). Taylor & Francis, 2020. https://www.taylorfrancis.com/chapters/edit/10.4324/9781315045337-16
35. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Research Synthesis Methods. 2021; 12(1):55-61. Doi: https://doi.org/10.1002/jrsm.1411
36. Meli K, Koliopoulos D, Lavidas K. A model-based constructivist approach for bridging qualitative and quantitative aspects in teaching and learning the first law of thermodynamics. Science & Education, 2022. Doi: https://doi.org/10.1007/s11191-021-00262-7
37. Mishra NR. Constructivist approach to learning: An analysis of pedagogical models of social constructivist learning theory. Journal of Research and Development. 2023; 6(1). Doi: https://doi.org/10.3126/jrdn.v6i01.55227
38. Mohammed SH, Kinyó L. The cross-cultural validation of the technology-enhanced social constructivist learning environment questionnaire in the Iraqi Kurdistan Region. Research and Practice in Technology Enhanced Learning. 2022; 17(1). Doi: https://doi.org/10.1186/s41039-022-00199-7
39. Mutende RA, Imonje R, Akala W. Pre-service science teachers' integration of constructivist ideas in the lecture method. International Journal of Learning, Teaching and Educational Research. 2021; 20(6):203-218. Doi: https://doi.org/10.26803/ijlter.20.6.15
40. Naureen G. Effect of constructivist teaching approach

on student's achievement in science at elementary level. Pakistan Social Sciences Review. 2020; 4(3):812-820. Doi: https://doi.org/10.35484/pssr.2020(4-iii)64
41. Ngo TTA. Natural science visual model videos for online learning: Effect on students' achievement in constructivist approach. Studies in Learning and Teaching. 2021; 2(1). Doi: https://doi.org/10.46627/silet.v2i1.56
42. Özkan EÇ. Perception of engineering students on social constructivist learning approach in classroom. International Journal of Engineering Pedagogy (iJEP). 2024; 14(1). Doi: https://doi.org/10.3991/ijep.v14i1.43101
43. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al*. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ. 2021; 372:n71. Doi: https://doi.org/10.1136/bmj.n71
44. Prayitno BA, Sugiharto B, Titikusumawati E. Effectiveness of collaborative constructivist strategies to minimize gaps in students' understanding of biological concepts. International Journal of Emerging Technologies in Learning (iJET). 2022; 17(11). Doi: https://doi.org/10.3991/ijet.v17i11.29891
45. Putri AS, Radandima GUE, Setiawan A. Analysis of the constructivist approach in the learning process of public policy. Jejaring Administrasi Publik. 2024; 16(2). Doi: https://doi.org/10.20473/jap.v16i2.53461
46. Quilloy RQ. Effectiveness of mathematics digitized activities for learners' intervention (Math-DALI) game apps to the mathematics performance of Grade 10 learners. SSRN Scholarly Paper, 2022. Doi: https://doi.org/10.2139/ssrn.4570177
47. Rababah EQ. From theory to practice: Constructivist learning practices among Jordanian kindergarten teachers. Cypriot Journal of Educational Sciences. 2021; 16(2):456-471. Doi: https://doi.org/10.18844/cjes.v16i2.5639
48. Richards DM, Birbal R, Ramdass M. The use of a constructivist blended approach to teaching geography in a secondary school. Asian Education Studies. 2020; 5(2):67-79. Doi: https://doi.org/10.20849/aes.v5i2.819
49. Sarwar MN, Shahzad A, Ullah Z, Raza S, Wasti SH, Shrahili M, *et al*. Concept mapping and conceptual change texts: A constructivist approach to address misconceptions in nanoscale science and technology. Frontiers in Education. 2024; 9:1339957. Doi: https://doi.org/10.3389/feduc.2024.1339957
50. Shemy N. Effect of different levels of constructivist scaffolding within e-content on undergraduate students' mastery of learning and their attitudes towards it. Journal of Education and e-Learning Research. 2022; 9(1):1-10. Doi: https://doi.org/10.20448/jeelr.v9i1.3737
51. Singh J. Critical appraisal skills programme. Journal of Pharmacology & Pharmacotherapeutics. 2022; 13(2):94-96. Doi: https://doi.org/10.4103/jpp.jpp_68_22
52. Soltura RT. Designing a constructivist learning aid module in disentangling least mastered competencies in the wave motion. Journal of Research in Instructional. 2022; 2(1):1-10. Doi: https://doi.org/10.30862/jri.v2i1.24
53. Syamsuddin IS. Innovative learning strategies to enhance student motivation and academic achievement: A constructivist learning perspective in Islamic religious education. International Journal of Scientific Research and Management (IJSRM). 2024; 12(9). Doi: https://doi.org/10.18535/ijsrm/v12i09.el04
54. Takıcak M. Constructivist approach in Ottoman mathematics education: Salih Zeki. Turkish Journal of Computer and Mathematics Education (TURCOMAT). 2021; 12(1). Doi: https://doi.org/10.17762/turcomat.v12i1.281
55. Ugwuozor FO, Ede MO, Abiogu GC, Ugwu JC, Ncheke DC, Nnamani A, *et al*. Effect of the constructivist method on junior secondary school students' achievement in poetry: Implications for school counseling in Nigeria. Global Journal of Health Science. 2020; 12(5). Doi: https://doi.org/10.5539/gjhs.v12n5p80
56. Uygun T, Güner P. Van Hiele levels of geometric thinking and constructivist-based teaching practices. Mersin Üniversitesi Eğitim Fakültesi Dergisi. 2021; 17(3):643-661. Doi: https://doi.org/10.17860/mersinefd.684571
57. Wang T, Chen Y, Li J. Exploring the impact of digital learning tools on mathematics achievement: A meta-analytic review. Journal of Computer Assisted Learning. 2022; 38(5):1258-1273. Doi: https://doi.org/10.1111/jcal.12691
58. Zhu Y, Nankhantee A, Jantharajit N. An experimental study on improving first-grade students' mathematical learning achievement and social awareness through an instructional approach based on constructivist theory and collaborative learning. Higher Education Studies. 2024; 14(3). Doi: https://doi.org/10.5539/hes.v14n3p1
59. Ziani M, Aoumeur H. A constructivist approach to teaching scientific content to university students. Technium Social Sciences Journal. 2022; 36(1). Doi: https://doi.org/10.47577/tssj.v36i1.7544