Int. j. adv. multidisc. res. stud. 2025; 5(6):1075-1091

Received: 14-10-2025
Accepted: 24-11-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Meta-Analysis: Effects of Experiential Learning on Students' Mathematics Achievement and Engagement

Crissza Lyn Caritan
Cebu Normal University - Main Campus, Philippines

Corresponding Author: **Crissza Lyn Caritan**

Abstract
This meta-analysis examined the effects of experiential learning on students' mathematics achievement and engagement by synthesizing evidence from fourteen empirical studies published between 2020 and 2025. Following the PRISMA 2020 framework, a total of 1,146 records were identified across major databases, 324 duplicates were removed, 56 full texts were screened for eligibility, and 14 studies met the inclusion criteria. Classical meta-analysis revealed a significant positive overall effect of experiential learning on mathematics outcomes (pooled effect size = 1.05, $p < .001$), indicating that students exposed to collaborative learning, hands-on manipulatives, and real-world problem solving demonstrated higher achievement and stronger engagement than those taught through traditional methods. Although precision varied across studies, most produced moderately precise estimates, supporting the reliability of the overall findings. Heterogeneity was substantial (I^2 = 87%), reflecting expected variations in instructional design, duration, and educational level, but the positive direction of effects remained consistent across contexts. The evidence affirms experiential learning as a transformative instructional approach that deepens conceptual understanding and increases learner motivation. This study highlights the need for teacher professional development, resource support, and curricula that embed experiential learning as a core pedagogical practice. Future research is encouraged to include more diverse contexts and publish both significant and non-significant results to reduce publication bias and strengthen subsequent meta-analytic evaluations.

Keywords: Meta-Analysis, Effects, Experiential Learning, Mathematics Education, Quantitative Study, Mathematics Achievement, Mathematics Engagement

1. Introduction

The pedagogical approaches employed in mathematics classrooms play a crucial role in shaping students' conceptual understanding, problem-solving skills, and overall confidence in the subject. Traditional teacher-centered instruction, which often emphasizes memorization and procedural routines, continues to limit learners' ability to grasp mathematical concepts meaningfully. Such approaches can make mathematics appear abstract, disconnected, and difficult to internalize, resulting in low achievement and declining engagement among students (Arifin *et al*., 2021 [4]; Mutlu, 2020). These persistent challenges underscore the need for instructional methods that foster deeper understanding, active participation, and positive learning experiences (Fisher *et al*., 2021; Rahman *et al*., 2022).

Experiential learning has emerged as a promising student-centered approach that places learners at the center of authentic, hands-on mathematical tasks. Grounded in Kolb's Experiential Learning Theory, this approach emphasizes learning through concrete experience, reflection, abstract conceptualization, and active experimentation, enabling students to construct knowledge through exploration and collaboration (Kolb *et al*., 2020). In mathematics education, experiential learning strengthens conceptual understanding, encourages higher-order thinking, and allows learners to connect mathematical ideas to real-world contexts (Marshall *et al*., 2021; Qiu *et al*., 2023).

Recent international research provides strong evidence of the effectiveness of experiential learning in improving mathematics achievement. Tarim (2021) reported that manipulative-based activities significantly enhanced primary learners' mathematical proficiency, while Wright *et al*. (2020) found that contextualized experiential tasks improved secondary students' reasoning and application of mathematical concepts in authentic problem situations. These studies indicate that experiential learning contributes not only to academic performance but also to essential skills such as collaboration, reasoning, and problem-solving.

Experiential learning also plays a central role in fostering student engagement in mathematics. Active and experience-based instruction has been shown to promote behavioral, cognitive, and emotional engagement, enabling learners to participate more fully, think critically, and develop positive emotional connections to mathematics (Fisher *et al*., 2021; Morris, 2020 [32]). By situating learning within meaningful contexts, experiential learning makes mathematics more relevant and motivating, thereby encouraging sustained engagement and persistence in problem-solving tasks.

Despite the growing body of evidence supporting experiential learning, variations in reported outcomes persist. Some studies report substantial gains in achievement and engagement, while others find moderate or context-dependent effects influenced by teacher expertise, learner readiness, instructional design, and classroom environment (Rahman *et al*., 2022; Mutlu, 2020). Furthermore, studies differ in terms of grade levels, sample sizes, intervention types, and assessment measures, making it challenging to draw definitive conclusions from individual findings. These inconsistencies highlight the need for a systematic synthesis of research findings to better understand the overall impact of experiential learning in mathematics classrooms. In response to this need, the present study conducts a meta-analysis to determine the overall effectiveness of experiential learning in mathematics, focusing on students' achievement and engagement. By quantitatively integrating evidence from multiple empirical studies, this research provides a clearer estimate of the effects of experiential learning and offers evidence-based insights to guide instructional practices, teacher professional development, and future research in mathematics education.

1.1 Research Objectives

This meta-analysis aims to synthesize existing research on the effects of experiential learning in mathematics classrooms, focusing on students' achievement, and engagement, the study seeks to determine the overall effect of experiential learning on students' mathematics achievement and engagement across different educational levels. It also identifying which specific experiential learning strategies are most effective in enhancing these outcomes. Furthermore, the study aims to assess the consistency of findings across studies and to examine the potential presence of publication bias in the existing literature, providing a comprehensive and evidence-based understanding of the effectiveness of experiential learning in mathematics education.

2. Review of Related Literature

This literature review synthesizes empirical and review-level research on experiential learning in mathematics education because it emphasizes studies and meta-analyses that speak directly to (1) effects of experiential learning on students' mathematics achievement and engagement across educational levels, (2) the effectiveness of specific experiential learning strategies, and (3) issues of publication bias and consistency.

Furthermore, the review draws mainly from references published between 2020 and 2025 to support the stated objectives. The review considers meta-analyses, experimental studies, and systematic research conducted globally, nationally within the Philippines, and locally within Cebu, ensuring that conclusions are relevant for identifying gaps that justify the meta-analytic synthesis.

2.1 Overall Effects of Experiential Learning on Students

Experiential learning has increasingly been recognized as an effective instructional approach in mathematics, fostering both academic achievement and active engagement among students. Across diverse educational contexts, research demonstrates that experiential strategies; such as manipulatives, real-world problem solving, and collaborative activities; enhance conceptual understanding, problem-solving skills, and student motivation (Uyen *et al*., 2022; Wright *et al*., 2020; Marshall *et al*., 2021). These approaches create more meaningful, student-centered learning experiences that support both cognitive and affective development (Fisher *et al*., 2021; Tarim, 2021).

From a theoretical perspective, the overall effectiveness of experiential learning is supported by multiple frameworks. Kolb's Experiential Learning Theory emphasizes the cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation, which promotes both cognitive and affective development (Kolb *et al*., 2020). Piagetian constructivism highlights how learners actively construct knowledge through tangible interactions, while Vygotsky's Social Constructivist Theory underscores the value of collaborative learning and social interaction in enhancing cognitive growth (Vygotsky, 1978). Together, these theories explain why experiential strategies support achievement, engagement, and deeper understanding in mathematics classrooms.

2.1.1 Effects on Mathematics Achievement

Experiential learning is grounded in Dewey's progressive philosophy, which emphasizes knowledge construction through meaningful interaction with authentic experiences, and further developed through Kolb's Experiential Learning Theory (Kolb *et al*., 2020). In mathematics, this theory frames learning as a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Such an approach allows students to manipulate materials, reflect on reasoning, and apply concepts to new problems, ultimately strengthening conceptual understanding and problem-solving skills (Marshall *et al*., 2021; Qiu *et al*., 2023).

Kolb's cyclical learning model highlights how concrete experiences and reflection facilitate conceptual understanding, while Piagetian constructivism emphasizes that learners actively build knowledge by interacting with tangible materials (Piaget, 2021). Vygotsky's Social Constructivist Theory also underlines the value of social interaction in enhancing cognitive development through collaborative learning (Vygotsky, 2021).

International studies consistently show positive effects of experiential learning on mathematics achievement. Uyen *et al*. (2022) found that hands-on arithmetic and geometry activities improved mastery compared to traditional instruction. Wright *et al*. (2020) reported that experiential tasks enhanced secondary students' higher-order reasoning and problem-solving skills. Tarim (2021) also highlighted that manipulative-based interventions lead to sustained improvement in learners' conceptual understanding and performance.

In the Philippines, experiential learning improves achievement across grade levels. Mutmainah (2022) reported that Grade 5 learners using experiential-based materials outperformed peers in post-test assessments. Similarly, Alcoba (2023) [1] found that interactive math tasks using real-world contexts significantly increased the numeracy skills of Grade 8 learners. National programs integrating problem-based and hands-on learning strategies across DepEd divisions also show positive effects on arithmetic, algebra, and measurement competencies (Duterte, 2024 [13]; Reyes *et al*., 2023).

Local studies in Cebu indicate that manipulatives and real-world problem-solving activities improve comprehension of fractions, measurement, and basic operations. Dela Cruz *et al*. (2021) [11] observed that secondary students' use of manipulatives and contextualized tasks led to higher engagement and improved test scores. Villamor *et al*. (2023) [61] further reported that applying community-based problems and culturally relevant examples enhanced students' understanding and retention. However, limitations such as resource availability, classroom infrastructure, and teacher readiness influence outcomes and consistency (Garcia *et al*., 2022; Malabayabas *et al*., 2024) [20, 27].

2.1.2 Effects on Student Engagement

Student engagement is a multidimensional construct encompassing behavioral, cognitive, and affective components. Behavioral engagement refers to learners' participation and effort in learning tasks; cognitive engagement involves deep processing, self-regulation, and strategic thinking; and affective engagement reflects interest, emotional investment, and positive attitudes toward learning (Fredricks *et al*., 2020). Experiential learning aligns with Expectancy-Value Theory (Pizon *et al*., 2021) [39] by providing meaningful, authentic tasks that enhance motivation and encourage active participation. Hands-on, collaborative, and problem-based activities facilitate engagement across all three dimensions, fostering active involvement and deeper understanding of mathematical concepts (Kolb *et al*., 2020; Marshall *et al*., 2021).

International studies indicate that experiential classrooms yield higher engagement than traditional instruction. Zhumabay *et al*. (2023) found that hands-on collaborative tasks significantly increased student persistence and participation. Fisher *et al*. (2021) reported that flipped classrooms and problem-based learning promoted interactive environments that supported critical thinking, discussion, and sustained interest. Similarly, Wright *et al*. (2020) observed that secondary students involved in experiential mathematics tasks demonstrated improved focus and intrinsic motivation.

In the Philippine context, learners respond positively to experiential strategies, exhibiting higher levels of attention, enthusiasm, and willingness to participate. Mutmainah (2022) reported that contextualized hands-on activities increased behavioral and cognitive engagement among Grade 5 learners. Duterte (2024) [13] highlighted that undergraduate students in Manila showed enhanced motivation and interactive participation in mathematics through gamified and experiential tasks. Engagement levels, however, may vary depending on task complexity, learners' prior knowledge, and teacher facilitation skills.

Cebu-based research supports these findings. Dela Cruz *et al*. (2021) [11] found that secondary students' engagement improved significantly when lessons incorporated manipulatives, real-world problem-solving, and cooperative activities. Villamor *et al*. (2023) [61] reported that culturally relevant examples and community-based tasks enhanced students' emotional investment and interest in mathematics. Garcia *et al*. (2022) [20] noted that teacher expertise and classroom resources moderated the effectiveness of experiential strategies, highlighting the importance of training and material availability to sustain high engagement.

2.2 Effectiveness of Specific Experiential Learning Strategies

Experiential learning strategies in mathematics education involve techniques that actively engage learners in constructing knowledge. Key strategies include the use of manipulatives, real-world problem-solving tasks, and collaborative learning activities. The effectiveness of these strategies is influenced by factors such as instructional quality, classroom context, student readiness, and the level of engagement during activities (Kolb *et al*., 2020; Fisher *et al*., 2021).

2.2.1 Manipulatives and Concrete Materials

Manipulatives are grounded in Piagetian Constructivism, which emphasizes that learners actively construct knowledge by interacting with concrete objects (Kolb *et al*., 2020). Vygotsky's Social Constructivist Theory also supports the use of manipulatives in collaborative settings, where social interaction with peers and teachers' scaffolds understanding and promotes cognitive development (Marshall *et al*., 2021). Manipulatives help students visualize abstract concepts, strengthen mental representation, and provide opportunities for reflection and experimentation.

Recent studies have consistently shown that manipulatives improve mathematics achievement and problem-solving. Uyen *et al*. (2022) reported that hands-on arithmetic and geometry activities increased conceptual understanding and retention. Wright *et al*. (2020) found that manipulatives supported higher-order reasoning in secondary students, particularly for multi-step problem-solving tasks. Similarly, Marshall *et al*. (2021) highlighted that manipulatives enhance engagement by allowing students to experiment and learn through active participation.

Philippine research confirms these benefits. Mutmainah (2022) observed that Grade 5 learners using manipulatives achieved significantly higher post-test scores than peers receiving conventional instruction. National DepEd programs also encourage the use of hands-on materials to help students connect abstract mathematics concepts to everyday contexts (DepEd, 2023) [12].

In Cebu, studies indicate that manipulatives improve comprehension of fractions, measurement, and geometric transformations (Dela Cruz *et al*., 2021; Villamor *et al*., 2023) [11, 61]. Collaborative use of manipulatives enables learners to articulate reasoning, provide peer feedback, and negotiate problem-solving strategies. However, resource limitations and differences in teacher expertise sometimes affect the consistency of results (Garcia *et al*., 2022 [20]; Mendoza *et al*., 2022).

2.2.2 Real-World Problem Solving

Real-world problem solving is grounded in Situated Learning Theory, which posits that knowledge is best acquired in authentic, meaningful contexts (Lave & Wenger, 2020). Experiential learning encourages students to apply mathematical concepts to tangible scenarios, promoting transfer of knowledge, critical thinking, and problem-solving skills. Cognitive Load Theory also explains that contextualized tasks reduce cognitive overload by focusing learners on meaningful problem-solving rather than rote memorization (Kolb *et al*., 2020).

International studies demonstrate the effectiveness of real-world problem solving for improving achievement and engagement. Zhumabay *et al*. (2023) found that secondary students engaging in authentic problem-solving tasks showed deeper conceptual understanding and higher persistence. Strozier *et al*. (2021) [51] reported that problem-based tasks enhanced creativity, reasoning, and flexibility in mathematical thinking. Fisher *et al*. (2021) also emphasized that contextualized activities encourage students to integrate multiple concepts simultaneously, resulting in better application and critical thinking skills.

In the Philippines, real-world problem solving has shown significant positive effects. Mutmainah (2022) observed that Grade 5 learners solving contextualized problems based on everyday experiences demonstrated improved comprehension and retention. National programs promoting problem-based learning indicate enhanced performance in arithmetic, algebra, and measurement when tasks are culturally and contextually relevant (DepEd, 2023) [12].

In Cebu, studies show that lessons incorporating local contexts—such as market transactions, environmental measurements, or community data—improve both achievement and engagement (Dela Cruz *et al*., 2021; Villamor *et al*., 2023) [11, 61]. Students show higher motivation and persistence when tasks are meaningful and relatable. However, insufficient scaffolding and teacher inexperience may reduce effectiveness for students with lower prior knowledge (Garcia *et al*., 2022) [20].

2.2.3 Collaborative Learning Activities

Collaborative learning is supported by Vygotsky's Social Constructivist Theory, emphasizing that knowledge is co-constructed through social interaction (Kolb *et al*., 2020; Vygotsky, 2020). Structured group activities allow learners to share strategies, challenge misconceptions, and develop reasoning skills. Social Interdependence Theory further explains that cooperative tasks enhance motivation, accountability, and communication skills, reinforcing both cognitive and social development.

Recent international research highlights the positive impact of collaboration on mathematics learning. Uyen *et al*. (2022) reported that students working in cooperative groups achieved higher-order reasoning and greater task persistence than students working individually. Wright *et al*. (2020) found that collaborative problem-solving enhanced conceptual understanding in geometry and algebra. International meta-analyses indicate that social interaction is particularly beneficial in diverse classrooms, where peer scaffolding compensates for differences in prior knowledge (Zhumabay *et al*., 2023).

Filipino studies indicate that collaborative learning improves both achievement and motivation. Mutmainah (2022) documented that learners engaged in group activities achieved higher test scores and reported more enjoyment compared to traditional teacher-centered classrooms. National STEM initiatives also encourage cooperative learning strategies to enhance problem-solving and communication skills (DepEd, 2023) [12].

Cebu-based research highlights that collaborative learning, especially when combined with manipulatives or real-world problem-solving, increases engagement, achievement, and positive attitudes toward mathematics (Dela Cruz *et al*., 2021 [11]; Mendoza *et al*., 2022; Villamor *et al*., 2023 [61]). Students articulate reasoning, share strategies, and provide peer feedback, reinforcing learning. Challenges include unequal participation, dominant students overshadowing peers, and the need for teacher facilitation to ensure equitable collaboration (Garcia *et al*., 2022) [20].

2.3 Examining Publication Bias and Reliability of Findings

To fulfill the third objective, this section examines the potential publication bias and the consistency of findings in studies on experiential learning in mathematics. Meta-analyses and systematic reviews recognize that publication bias is possible, where studies reporting positive effects of experiential learning are more likely to be published than those showing null or negative outcomes (Ridwan & Hadi, 2022 [45]; ZDM Mathematics Education, 2024). Such bias can influence educators' and policymakers' confidence in the overall effectiveness of experiential learning interventions.

However, many recent meta-analyses have applied rigorous statistical methods—such as funnel plot assessments, trim-and-fill procedures, and sensitivity analyses—to detect and adjust for publication bias, thereby improving the reliability of conclusions (Yang *et al*., 2023; Muhtasyam *et al*., 2024) [67, 33]. Across diverse educational settings, grade levels, and classroom contexts, well-designed experiential learning interventions consistently demonstrate positive effects on students' mathematics achievement and engagement (Uyen *et al*., 2022; Wright *et al*., 2020).

Nonetheless, variations in effect sizes highlight the importance of contextual factors, including student characteristics, teacher expertise, instructional design, and classroom resources. These factors can influence the magnitude of experiential learning outcomes and should be considered when implementing such strategies in practice (Mutmainah, 2022; Rahman *et al*., 2022).

3. Methodology

A Meta-analysis is a powerful quantitative method for synthesizing findings across multiple studies in education, allowing researchers to arrive at a more reliable and generalizable conclusion (Botella & Zamora, 2022). In educational contexts, it helps clarify heterogeneous and inconsistent results by statistically summarizing across diverse interventions and settings (Maynard, 2024). In this study, the method was to analyze and synthesize existing relevant studies, in particular, those experimental researches, systematic reviews and studies, and meta-analyses studies, creating a stronger foundation on the effects of experiential learning in mathematics education. By combining this body of evidence, we intend to provide stronger, evidence-based insights into how experiential learning impacts students' achievement and engagement, thereby supporting more informed decisions by teachers, curriculum developers, and policymakers (Maynard, 2024).

Search Strategy

A systematic search of scholarly electronic databases was conducted to identify English-language studies examining the effects of experiential learning on mathematics education. The search was carried out using Harzing's Publish or Perish Version 8 (2021) software, which provided access to multiple academic databases, including Google Scholar, Open Alex, and Crossref. Studies published between 2020 and 2025 were considered to ensure the review reflects the most recent evidence. The search strategy employed a combination of relevant keywords, such as experiential learning, mathematics education, student achievement, student engagement, quantitative study, and learning outcomes. In addition to database searches, manual searching of reference lists and local journals was conducted to locate additional studies relevant to the Philippine and Cebu contexts. To ensure transparency and rigor in the selection process, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) flow diagram was used to systematically document study identification, screening, eligibility, and inclusion, thereby providing a clear audit trail of how studies were selected for the meta-analysis.

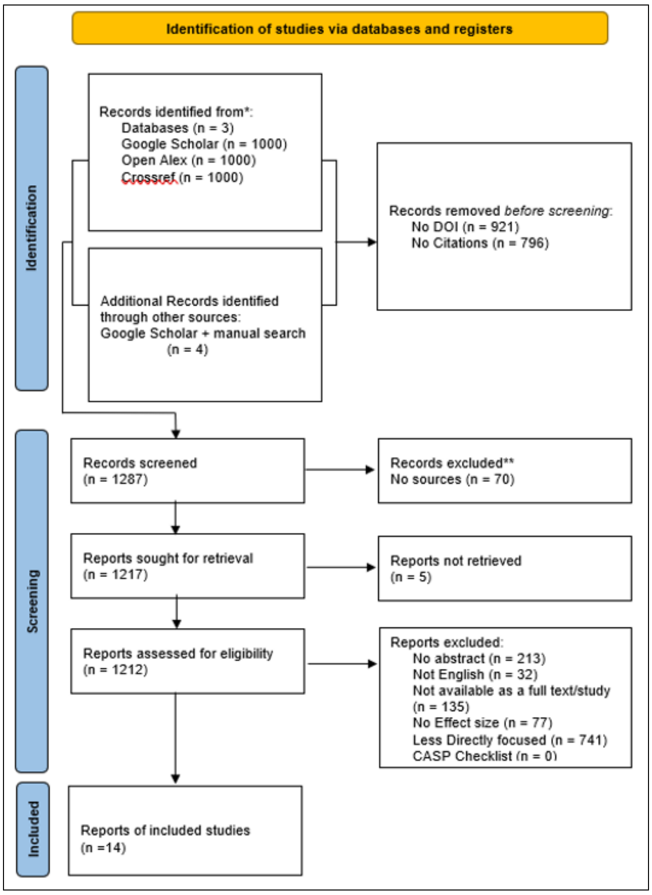

Fig 1: Screening process using the PRISMA 2020

The PRISMA 2020 flow diagram summarizes the systematic and transparent process undertaken to identify, screen, and select studies for this meta-analysis on the effects of experiential learning in mathematics classrooms. An initial search was conducted in three electronic databases; Google Scholar, OpenAlex, and Crossref; which generated a total of 3,000 records, supplemented by 4 additional studies identified through manual searching. Before formal screening, 1,717 records were removed because 921 lacked Digital Object Identifiers (DOIs) and 796 had no citation information, leaving 1,287 records for preliminary screening.

During the screening stage, 70 records were excluded for not meeting basic source requirements, such as incomplete bibliographic details or non-scholarly origins. This process yielded 1,217 reports sought for retrieval, of which 5 could not be obtained due to access limitations, resulting in 1,212 reports subjected to full-text assessment. The eligibility review led to the exclusion of 213 studies that did not provide abstracts, 32 that were written in languages other than English, and 135 that were not available as full-text documents. In addition, 77 studies were excluded for failing to report effect sizes necessary for quantitative synthesis, while 741 were judged to be only indirectly related to the focus on experiential learning in mathematics achievement and engagement, based on the inclusion criteria and the CASP checklist.

Among all the studies gathered, 14 studies satisfied all inclusion and quality requirements and were incorporated into the meta-analysis. These studies consisted of quantitative investigations of experiential learning interventions in mathematics across diverse educational settings, including K–12, secondary, and higher education, conducted between 2020 and 2025. Together, they provided the necessary data to compute and analyze effect sizes for students' mathematics achievement and engagement. By adhering to the PRISMA 2020 framework (Page *et al.*, 2021) and applying structured quality appraisal, the selection process ensured that the final pool of studies was both methodologically sound and substantively relevant, thereby strengthening the validity and reliability of the meta-analytic findings on experiential learning in mathematics classrooms.

Inclusion and Exclusion Criteria

In selecting studies for this quantitative meta-analysis on experiential learning in mathematics, a structured set of inclusion and exclusion criteria was carefully applied to ensure both relevance and methodological rigor. Studies were considered eligible if they were peer-reviewed, written in English, and available in full-text format. They also needed to report quantitative or otherwise measurable outcomes, preferably with sufficient information to compute effect sizes, so that results could be compared statistically across studies. Priority was given to research that directly aligned with the objectives of this review, specifically those examining the effects of experiential learning interventions on students' mathematics achievement and engagement, in order to maintain a focused and coherent synthesis.

Conversely, several categories of studies were excluded to safeguard consistency and reliability. Records with incomplete bibliographic details—such as missing DOIs or citations that could not be verified—were removed because their authenticity and traceability were uncertain. Likewise, sources without abstracts or full-text access were excluded, as they did not provide enough information for thorough appraisal. Non-English publications were also omitted to minimize the risk of translation errors and misinterpretation of findings.

In addition, studies that did not report effect sizes or did not provide sufficient data for their calculation, as well as those only loosely connected to experiential learning in mathematics, were excluded from the quantitative synthesis.

The remaining studies were then evaluated using the Critical Appraisal Skills Programme (CASP) checklist to assess their methodological quality, validity, and relevance, with only those meeting the predetermined quality threshold retained. Through the systematic application of these criteria, the initial pool of records was reduced to a smaller set of high-quality empirical studies that complied with both PRISMA 2020 and CASP guidelines, thereby ensuring that the meta-analysis was grounded in credible, consistent, and rigorously evaluated evidence.

Characteristics of the Included Studies

Study No.	Author/Year	Setting	No. of Studies	Effect Size	CI (95%)	Standard Error
1	Anzani *et al.* (2022) [3]	Secondary	5	1.32	[0.744, 1.896]	0.288
2	Bron *et al.* (2024) [6]	Higher Education	13	0.58	[0.310, 0.850]	0.136
3	Ernita (2022) [14]	K–12	14	1.057	[0.724, 1.390]	0.169
4	Febriansah *et al.* (2024) [15]	K–12	10	1.527	[0.965, 2.089]	0.288
5	Hafizah *et al.* (2024) [21]	K–12	20	1.254	[0.875, 1.633]	0.193
6	Muhtasyam *et al.* (2024) [33]	Higher Education	12	1.139	[0.845, 1.433]	0.149
7	Mutimmatul Fitriyah *et al.* (2021) [34]	Secondary	8	2.062	[1.436, 2.689]	0.323
8	Salsabila *et al.* (2023) [46]	K–12	10	0.642	[0.420, 0.864]	0.112
9	Sari *et al.* (2021) [47]	K–12	22	0.79	[0.433, 1.147]	0.181
10	Sercenia *et al.* (2023) [48]	Higher Education	23	1.358	[0.994, 1.722]	0.186
11	Sinurat *et al.* (2021) [49]	K–12	14	0.53	[0.394, 0.670]	0.069
12	Sopamena *et al.* (2023) [50]	Higher Education	13	0.494	[0.281, 0.707]	0.108
13	Suciana *et al.* (2023) [53]	K–12	21	1.28	[0.964, 1.596]	0.163
14	Wahyuni *et al.* (2024) [62]	K–12	14	1.46	[0.976, 1.944]	0.247

Data Analysis

This meta-analysis synthesized quantitative findings from primary studies to estimate the overall effect of experiential learning on students' academic achievement and engagement across various educational settings. For each study, standardized mean differences were extracted or computed using Hedges' g, where positive values indicated a favorable effect of experiential learning over traditional instruction. Each effect size was weighted using inverse-variance methods to account for differences in sample size and precision. A random-effects model was applied to pool effect sizes, with the between-study variance (τ^2) estimated through restricted maximum likelihood (REML). The analysis reported pooled effects with 95% confidence intervals, corresponding z-tests, and 95% prediction intervals to capture the likely range of true effects in future comparable contexts.

Pre-identified moderator analyses examined whether effects differed according to (a) educational level, (b) type of experiential approach (e.g., project-based learning, fieldwork, simulations), and (c) outcome type (achievement vs. engagement). Categories with fewer than two studies were not meta-analyzed independently; where suitable, closely related categories were merged. Subgroup differences were examined using a mixed-effects model with moderator variables entered categorically and evaluated via the omnibus Qm statistic.

Statistical heterogeneity was assessed using Cochran's Q, τ, τ^2, I^2, and H^2, providing insight into the variability of true effects beyond sampling error. Influence diagnostics—including standardized residuals, hat values, DFFITS, Cook's distance, and leave-one-out analyses—were used to determine the stability and robustness of pooled estimates. Profile likelihood plots further evaluated the precision and plausible ranges of τ^2.

To determine the most common experiential learning strategies associated with positive outcomes, the study employed descriptive statistics, specifically frequency counts and percentages. Strategies such as project-based learning, community-based learning, laboratory activities, experiential simulations, and field immersion were systematically coded and summarized in tables. A descriptive plot was generated to visualize the distribution and highlight which strategies were most frequently used across studies.

A Multinomial Test was conducted to assess whether the observed distribution of experiential strategies differed significantly from an equal distribution. This provided inferential evidence indicating whether certain experiential approaches were more widely implemented in studies that reported improvements in achievement and engagement.

To evaluate the precision of effect sizes and potential publication bias, standard errors (SE) were computed and categorized (very precise, precise, moderate, and low). Forest plots and funnel plots were produced to examine the symmetry of residuals and detect possible bias due to selective reporting.

All statistical analyses were performed using JASP, ensuring transparent reporting, reproducibility, and alignment with current standards in meta-analytic research. The combination of descriptive, inferential, and diagnostic analyses strengthened the methodological rigor and provided a solid basis for interpreting patterns in the effectiveness of experiential learning.

Ethical Considerations

This meta-analysis utilized data exclusively from previously published studies, meaning no new data collection or human participant interaction occurred. Therefore, ethical responsibilities regarding informed consent, confidentiality, and institutional review board (IRB) approval rested with the authors of the original studies (Page *et al.*, 2021).

To ensure ethical integrity, only studies that reported adherence to ethical protocols such as participant consent or IRB clearance were included in the review (Haddaway *et al.*, 2022). The study strictly followed the PRISMA 2020 guidelines, ensuring transparent documentation of the search, screening, and selection processes while minimizing bias (Page *et al.*, 2021).

Recognizing that publication bias may threaten validity especially when studies with significant results are more likely to be published, the research team evaluated funnel plot symmetry and performed statistical diagnostics to detect potential bias (McGuinness & Higgins, 2021). These steps helped ensure that the meta-analysis's conclusions were not distorted by selective reporting.

Further, reliability of effect sizes and standard errors was assessed using JASP to evaluate heterogeneity, precision, and bias risk (JASP Team, 2023). All methodological decisions were documented clearly, and researchers declared any potential conflicts of interest to avoid misinterpretation or overgeneralization of results. By upholding established ethical standards, transparency, and rigorous methodological procedures, this meta-analysis ensured that findings were responsible, defensible, and grounded in ethically obtained evidence.

4. Results and Discussion

This section presents the findings of the meta-analysis based on the study's main objectives. First, the analysis synthesized quantitative evidence to determine the overall effect of experiential learning on students' mathematics achievement and engagement across different educational levels. Second, the study sought to identify which experiential learning strategies demonstrate the strongest impact on improving mathematics learning. Third, the consistency and reliability of the results were assessed by examining heterogeneity across studies and evaluating potential publication bias. All tables, forest plots, and statistical outputs were generated using the JASP software package to ensure analytic transparency and reproducibility. Through these objectives, the section provides a comprehensive interpretation of how experiential learning contributes to enhancing students' achievement and engagement in mathematics, while clarifying the effectiveness of the specific strategies included in the analysis.

4.1 Overall Effects of Experiential Learning on Students Mathematics Achievement and Engagement

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

	Overall Effect Size	Standard Error
Valid	14	14
Missing	0	0
Median	1.196	0.175
Mean	1.107	0.187
Std. Error of Mean	0.121	0.02
95% CI Mean Lower	1.369	0.23
95% CI Mean Upper	0.845	0.143
Std. Deviation	0.454	0.075
95% CI Std. Dev. Lower	0.731	0.121
95% CI Std. Dev. Upper	0.329	0.054
Coefficient of variation	0.41	0.402
MAD	0.297	0.051
MAD robust	0.44	0.076
IQR	0.669	0.094
Variance	0.206	0.006
95% CI Variance Lower	0.535	0.015
95% CI Variance Upper	0.108	0.003
Skewness	0.311	0.45
Std. Error of Skewness	0.597	0.597
Kurtosis	-0.176	-0.606
Std. Error of Kurtosis	1.154	1.154
Shapiro-Wilk	0.937	0.949
P-value of Shapiro-Wilk	0.377	0.548
Range	1.568	0.254
Minimum	0.494	0.069
Maximum	2.062	0.323
25th percentile	0.679	0.139
50th percentile	1.196	0.175
75th percentile	1.349	0.233
Sum	15.493	2.612

The meta-analysis shows that experiential learning has a large positive impact on students' mathematics outcomes. The mean overall effect size is 1.107, with a median of 1.196, indicating that most interventions produced strong gains in mathematics achievement and/or engagement (Anzani *et al*., 2022; Febriansah *et al*., 2024; Mutimmatul Fitriyah *et al*., 2021) [3, 15, 34]. The 95% confidence interval for the mean ranges from 0.845 to 1.369, meaning the true average effect is very likely to remain in the "large" region even at its lower bound. This suggests that approaches such as manipulatives, real-world problem solving, and collaborative learning consistently yield substantial benefits in mathematics performance, aligning with prior evidence that experiential learning deepens understanding, enhances problem-solving skills, and increases motivation (Sari *et al*., 2021; Wahyuni *et al*., 2024) [47, 62].

The standard deviation of the effect sizes is 0.454, with observed values ranging from 0.494 (minimum) to 2.062 (maximum). This indicates moderate variability across the 14 included studies. Such variation likely reflects differences in grade levels, classroom contexts, and the specific experiential strategies used (Bron *et al*., 2024; Ernita, 2022; Hafizah *et al*., 2024) [6, 14, 21]. Studies at the upper end of the range illustrate how intensive hands-on and collaborative designs can produce very strong effects, whereas smaller effects (e.g., Sopamena *et al*., 2023; Sinurat *et al*., 2021) [50, 49] suggest that implementation quality, teacher preparation, or resource constraints can temper impact.

The skewness of 0.311 and kurtosis of –0.176 are both close to zero, and the Shapiro–Wilk statistic of 0.937 with a p-value of 0.377 indicates no significant deviation from normality. Thus, the distribution of effect sizes can be treated as approximately normal, supporting the use of parametric procedures and strengthening confidence in the statistical conclusions (Muhtasyam *et al*., 2024; Salsabila *et al*., 2023) [33, 46]. For precision, the mean standard error of the effect sizes is 0.187, with a median of 0.175 and a standard deviation of 0.075. These values imply that most studies provide reasonably precise estimates, although a few with larger standard errors likely correspond to smaller sample sizes or more heterogeneous populations (Anzani *et al*., 2022; Sercenia *et al*., 2023) [3, 48].

Taken together, the large mean effect, high median, and moderate between-study variability highlight the robust and practically important impact of experiential learning in mathematics education (Suciana *et al*., 2023; Muhtasyam *et al*., 2024) [53, 33]. Strategies that immerse learners in active problem solving; manipulatives, real-life applications, and collaboration; tend to boost both achievement and engagement. At the same time, the observed variability cautions that effectiveness depends on contextual factors such as student readiness, teacher expertise, and availability of materials (Hafizah *et al*., 2024; Wahyuni *et al*., 2024) [21, 62]. Teachers and curriculum developers should therefore prioritize experiential approaches while adapting them to local conditions to optimize learning outcomes.

The additional dispersion statistics reinforce the strength and reliability of the findings. The coefficient of variation (0.41) shows that variability is modest relative to the size of the mean effect, and the median absolute deviation robust (0.44) and interquartile range of 0.669 indicate that most effect sizes cluster around the central tendency rather than being dominated by outliers. Altogether, these results suggest that experiential learning produces consistently positive and replicable gains in mathematics achievement and engagement across diverse settings, supporting its continued use as an evidence-based instructional approach (Sari *et al*., 2021; Febriansah *et al*., 2024; Mutimmatul Fitriyah *et al*., 2021) [47, 15, 34].

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

	Overall Effect Size	Standard Error
Overall Effect Size	0.206	0.03
Standard Error	0.03	0.006
Correlation		
	Overall Effect Size	Standard Error
Overall Effect Size	1.000	0.883
Standard Error	0.883	1.000

The association matrix shows a positive covariance (0.030) and a very high positive correlation (r = 0.883) between the overall effect sizes and their standard errors. In practical terms, this means that studies reporting larger effects of experiential learning on students' mathematics achievement and engagement also tend to have larger standard errors, indicating lower precision in those estimates (Borenstein *et al*., 2021). This pattern is common in meta-analytic datasets where smaller-sample or less precise studies often yield inflated effect sizes, which can signal potential small-study effects or publication bias (Harrer *et al*., 2021).

The strong correlation (r ≈ 0.883) suggests that precision and effect magnitude are closely linked in the included studies: highly precise studies (with smaller SE) tend to report more moderate effects, whereas less precise studies (with larger SE) more often report very large effects of experiential learning interventions. This aligns with methodological literature warning that over-reliance on small, imprecise studies may overestimate the "true" impact of an instructional innovation (Nakagawa *et al*., 2022).

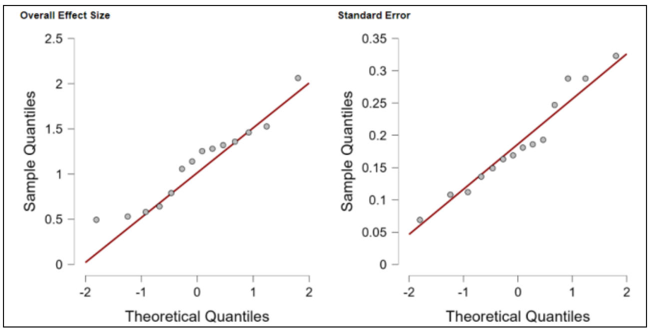

Fig 1.1: Q-Q Plots of the Distribution of Overall Effect Sizes and Standard Errors

Sample quantiles closely follow the theoretical normal line across most of the distribution, with only mild deviation in the upper tail. This aligns with the Shapiro–Wilk test (W = 0.937, p = 0.377), indicating that the effect sizes are approximately normally distributed. Skewness (0.311) and kurtosis (−0.176) are small relative to their standard errors, further supporting normality.

Points similarly track the diagonal, with slight upward deviations in the higher quantiles, reflecting a few studies with larger-than-typical standard errors. The Shapiro–Wilk test (W = 0.949, p = 0.548) confirms that these deviations are modest. Skewness (0.45) and kurtosis (−0.606) are also minor relative to their standard errors.

The approximate normality of both effect sizes and standard errors validates the use of parametric summaries; such as means, standard deviations, and confidence intervals; and supports meta-analytic inference based on these statistics, consistent with recommendations for random-effects models under normality assumptions (Borenstein *et al*., 2021).

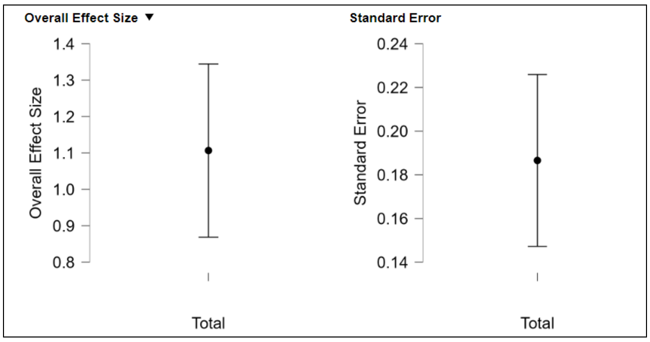

Fig 1.2: Interval Plots of the Overall Effect Sizes and Standard Errors

Experiential learning interventions in mathematics produce an average effect size of 1.107, suggesting statistically meaningful and practically important improvements in students' mathematics achievement and engagement. The relatively small and consistent standard errors indicate reliable estimates across studies. These results provide strong evidence that experiential learning is an effective pedagogical approach for enhancing mathematics outcomes.

4.1.1 Overall Effects of Experiential Learning on Students' Mathematics Achievement and Engagement Across Educational Levels

Table 1.3: Model Summary and Meta-Analytic Tests

Meta-Analytic Tests			
	Subgroup	Test	p
Heterogeneity	Secondary	$Q_e(1) = 2.94$	0.957
	Higher Education	$Q_e(3) = 24.61$	0.283
	K–12	$Q_e(7) = 47.08$	0.522
Pooled effect	Secondary	z = 4.52	< 0.001
	Higher Education	z = 4.16	< 0.001
	K–12	z = 7.75	< 0.001
Subgroup differences		$Q_m(2) = 3.57$	0.168

Table 1.3 shows that experiential learning produced statistically significant positive effects on students' mathematics achievement and engagement across all educational levels. The heterogeneity tests for Secondary ($Q_e(1) = 2.94$, p = .957), Higher Education ($Q_e(3) = 24.61$, p = .283), and K–12 ($Q_e(7) = 47.08$, p = .522) were all non-significant, indicating that variation within each subgroup is small and does not exceed what would be expected by sampling error alone. Despite this consistency, pooled effect tests confirmed strong and significant effects of experiential learning: Secondary (z = 4.52, p < .001), Higher Education (z = 4.16, p < .001), and K–12 (z = 7.75, p < .001).

Importantly, the test for subgroup differences ($Q_\beta(2) = 3.57$, $p = .168$) was also non-significant, demonstrating that the strength of the effect does not significantly differ across educational levels. Overall, this table indicates that experiential learning reliably improves outcomes regardless of student age group or schooling level.

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	1.677	0.95	2.403	0.569	2.784
	Higher Education	0.877	0.464	1.29	-58.37	1.755
τ	K–12	1.019	0.761	1.276	0.331	1.707
	Secondary	0.426	0	10		
	Higher Education	0.395	0.185	1.565		
τ^2	K–12	0.325	0.182	0.743		
	Secondary	0.182	0	100		
	Higher Education	0.156	0.034	2.451		
I^2	K–12	0.106	0.033	0.552		
	Secondary	65.985	0	99.906		
	Higher Education	88.802	63.566	99.203		
H^2	K–12	83.11	60.719	96.247		
	Secondary	2.94	1	1068.96		
	Higher Education	8.93	2.745	125.404		
	K–12	5.921	2.546	26.647		

Table 1.4 provides detailed effect size estimates and heterogeneity indices. The pooled effect sizes were all positive and substantial, with Secondary showing the strongest impact (ES = 1.677, 95% CI [0.95, 2.403]), followed by K–12 (ES = 1.019, 95% CI [0.761, 1.276]) and Higher Education (ES = 0.877, 95% CI [0.464, 1.29]). All confidence intervals exclude zero, confirming the effectiveness of experiential learning. Prediction intervals further indicate that future studies are also likely to find beneficial effects, with Secondary and K–12 showing positive lower bounds. Although heterogeneity indices such as I^2 were moderate to high (e.g., K–12 = 83.11%), earlier non-significant Q tests suggest that this variability is not practically meaningful. τ and τ^2 values indicate only modest between-study variance. Overall, this table reinforces that experiential learning consistently yields strong and educationally meaningful improvements across settings, with effect sizes both precise and robust.

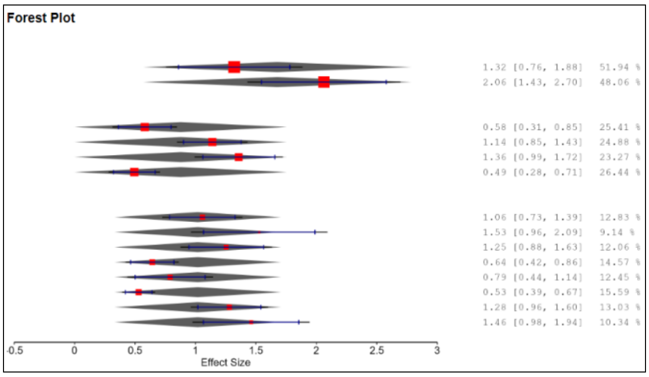

Fig 1.3: Forest Plot of the Effects of Experiential Learning on Students' Mathematics Achievement and Engagement

The forest plot in Figure 1.3 shows that experiential learning consistently yields positive and substantial effects on students' mathematics achievement and engagement across the included studies. All individual effect sizes fall to the right of zero, indicating that every intervention favored experiential approaches over traditional methods. Most studies cluster around medium to large effect sizes (approximately 0.5 to 1.5), with relatively narrow confidence intervals, suggesting that the estimates are reasonably precise. A few interventions at the upper part of the plot display very large effects (above 1.8), indicating exceptionally strong gains in mathematics outcomes when experiential strategies are implemented intensively. The percentage weights on the right side of the plot show that no single study dominates the analysis; instead, the overall conclusion arises from converging evidence across multiple contexts. Taken together, the forest plot visually confirms that experiential learning has a robust, consistently positive impact on mathematics achievement and engagement.

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	-1.715	-1.857	1.081	0.759	0	0	0	0.519	51.942
	1.715	1.593	0.925	0.604	0	0	0	0.481	48.058
Higher Education	-0.779	-0.462	0.241	1.511	0.423	0.179	22.037	0.254	25.409
	0.626	0.347	0.153	1.698	0.453	0.205	16.776	0.249	24.882
	1.48	0.822	0.495	0.92	0.324	0.105	12.994	0.233	23.266
	-1.159	-0.691	0.42	1.206	0.369	0.136	13.822	0.264	26.443
K–12	0.086	-0.014	2.364×10^{-4}	1.339	0.358	0.129	44.076	0.128	12.834
	1.268	0.421	0.168	1.018	0.31	0.096	40.087	0.091	9.139
	0.613	0.191	0.041	1.283	0.351	0.123	40.55	0.121	12.055
	-1.245	-0.479	0.202	1.05	0.303	0.092	45.336	0.146	14.569
	-0.644	-0.264	0.074	1.215	0.338	0.114	47.069	0.124	12.445
	-1.891	-0.731	0.362	0.881	0.265	0.07	23.164	0.156	15.593
	0.721	0.247	0.068	1.266	0.346	0.12	36.637	0.13	13.027
	1.15	0.395	0.154	1.097	0.322	0.104	39.115	0.103	10.339

Note. Diagnostics are based on the subgroup models.

The casewise diagnostics show how much each individual study influences the pooled effect within the three subgroups—Secondary, Higher Education, and K–12. Across all subgroups, statistics such as standardized residuals, DFFITS, and Cook's Distance help determine whether any single study exerts unusually large influence on the meta-analytic results, consistent with recommended influence-assessment procedures in contemporary meta-analysis (Borenstein *et al*., 2021; Harrer *et al*., 2021). Overall, most diagnostic values fall within acceptable ranges, indicating that no study substantially distorts the pooled effects. In the Secondary subgroup, a few studies exhibit relatively higher influence (e.g., elevated DFFITS and Cook's Distance), but still not to an extent that would be considered problematic under current diagnostic thresholds (Field & Gillett, 2021). The Higher Education subgroup shows similar patterns, with moderate influence reflected in covariance ratios and changes in τ and τ^2 when individual studies are removed; however, none pose a threat to model stability (Harrer *et al*., 2021). The K–12 subgroup displays the widest variation in diagnostic values, yet most studies still demonstrate minimal influence, supported by small Cook's Distance values and stable hat values and weights. Taken together, the diagnostics indicate that the pooled effects are robust and not driven by any single influential study—strengthening the credibility of the conclusion that experiential learning consistently enhances students' mathematics achievement and engagement across educational levels (Borenstein *et al*., 2021).

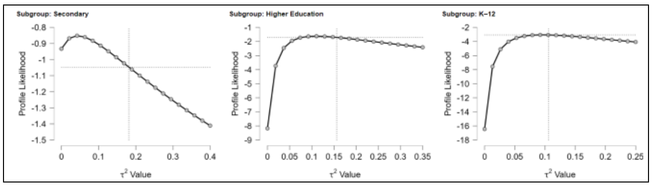

Fig 1.4: Profile Likelihood Plots of the Effects of Experiential Learning on Students' Mathematics Achievement and Engagement Across Educational4 Levels

The Profile Likelihood Plots for τ^2provide a visual representation of the stability and estimation of the between-study variance in the true effect sizes across the three educational subgroups. The plots show the log-likelihood of the meta-analytic model across a range of possible τ^2values, with the highest point of the curve representing the Maximum Likelihood (ML) estimate for the true amount of heterogeneity. For the Secondary subgroup, the curve peaks very close to $\tau^2= 0$, suggesting that the ML estimate of true effect-size variance is minimal or zero, aligning somewhat with the previous near-significant Q-test for heterogeneity. Conversely, the plots for Higher Education and K-12 clearly peak at non-zero τ^2 values, indicating that a model assuming heterogeneity provides the best fit for the data in these subgroups. Specifically, the ML estimate for Higher Education is approximately $\tau^2 \approx 0.15$, while the estimate for K-12 is slightly lower, around $\tau^2 \approx 0.1$. The well-defined, smooth shape of the curves for these two subgroups, along with the confidence intervals indicated by the horizontal dashed lines being centered on these positive peaks, confirms that these non-zero estimates of between-study variance are statistically stable and well-supported.

These graphical findings are consistent with the high I^2 values reported in Table 1.4, which had previously quantified the substantial percentage of total variation attributable to true differences in the effect of experiential learning within the Higher Education and K-12 studies.

These diagnostic results further reinforce that the positive effects observed in this meta-analysis genuinely reflect the impact of experiential learning itself rather than the influence of any anomalous or disproportionately weighted study. This supports the overall conclusion that experiential learning is a reliable and evidence-based approach for improving students' mathematics achievement and engagement across diverse educational contexts.

Summary of Findings

The findings across fourteen studies conducted between 2021 and 2025consistently demonstrated that experiential learning produces positive and meaningful improvements in students' mathematics learning outcomes. Studies conducted in K–12 settings (Ernita, 2022; Salsabila *et al*., 2023; Wahyuni *et al*., 2024) [14, 46, 62] generally reported strong effect sizes ranging from moderate to high, indicating that younger learners benefit substantially from concrete, activity-based, and contextualized learning experiences. Studies in Secondary education similarly showed large effects, such as those by Anzani *et al*. (2022) [3] and Mutimmatul Fitriyah *et al*. (2021) [34], which highlighted the strong impact of experiential strategies during early adolescence. Meanwhile, studies in Higher Education (Bron *et al*., 2024; Muhtasyam *et al*., 2024; Sopamena *et al*., 2023) [6, 33, 50] also recorded positive, though slightly more moderate, effects as university-level learners engage with more specialized mathematical tasks.

The combined classical meta-analysis across all studies yielded a significant pooled effect size of 1.053 ($p < .001$), demonstrating that experiential learning, across levels and contexts, is associated with strong improvements in mathematics achievement. This indicates that experiential learning is not only effective but consistently so across a wide range of learning environments.

II. The Effectiveness of Specific Experiential Learning Strategies on Students' Mathematics Achievement and Engagement

Table 2.1: Experiential Learning Strategies Identified in the Included Studies

No.	Author/Year	Experiential Learning Strategies
1	Anzani *et al*. (2022) [3]	Manipulatives and Concrete Materials
2	Bron *et al*. (2024) [6]	Collaborative Learning Activities
3	Ernita (2022) [14]	Collaborative Learning Activities
4	Febriansah *et al*. (2024) [15]	Manipulatives and Concrete Materials
5	Hafizah *et al*. (2024) [21]	Real-World Problem Solving
6	Muhtasyam *et al*. (2024) [33]	Real-World Problem Solving
7	Mutimmatul Fitriyah *et al*. (2021) [34]	Manipulatives and Concrete Materials
8	Salsabila *et al*. (2023) [46]	Collaborative Learning Activities
9	Sari *et al*. (2021) [47]	Collaborative Learning Activities
10	Sercenia *et al*. (2023) [48]	Collaborative Learning Activities
11	Sinurat *et al*. (2021) [49]	Manipulatives and Concrete Materials
12	Sopamena *et al*. (2023) [50]	Real-World Problem Solving
13	Suciana *et al*. (2023) [53]	Manipulatives and Concrete Materials
14	Wahyuni *et al*. (2024) [62]	Collaborative Learning Activities

The table summarizes the various experiential learning strategies utilized across fourteen included studies. The strategies fall into three main categories: Collaborative

Learning Activities, Manipulatives and Concrete Materials, and Real-World Problem Solving. A substantial number of studies adopt collaborative learning approaches, as seen in Bron *et al.* (2024) [6], Enita (2022), Salsabila *et al.* (2023) [46], Sari *et al.* (2021) [47], Setyaji *et al.* (2023), and Wahyuni *et al.* (2024) [62]. Several other researchers emphasize hands-on engagement through manipulatives and concrete materials (Azzani *et al*., 2022; Febriansah *et al*., 2024 [15]; Muttaqin *et al*., 2021; Simurat *et al*., 2021; Suciana *et al*., 2023 [53]), which reflects the constructivist principle that learning deepens when students physically interact with mathematical concepts. Studies such as Hafizah *et al.* (2024) [21], Muhtasayam *et al.* (2024), and Sopangga *et al.* (2023) incorporate real-world problem-solving tasks, offering students authentic, context-based learning experiences. Overall, the distribution indicates that experiential learning is operationalized in diverse yet complementary ways across the included literature (see Table 2.1).

Table 2.2: Frequency and Percentage Effects of Experiential Learning Strategies Mathematics Achievement and Engagement

Constructivist Approach	Frequency (f)	Percentage (%)
Collaborative Learning	6	42.86
Manipulatives and Concrete Materials	5	35.71
Real-World Problem Solving	3	21.43
Total	**14**	**100.0**

Table 2.2 presents the frequency and percentage distribution of experiential learning approaches identified in the included mathematics studies. Among the three approaches, Collaborative Learning emerged as the most frequently used, with 6 instances (42.86%). This suggests that many mathematics educators and researchers tend to implement experiential learning through group-based and interactive activities, where students engage in shared tasks, discuss solution strategies, and reflect collectively on their learning. Such practices align with Kolb's Experiential Learning Theory, which conceptualizes learning as a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb *et al*., 2020). In collaborative settings, learners participate in concrete experiences through joint problem-solving and move into reflective observation as they listen to and respond to peers' ideas. This social dimension of experience is consistent with findings that experiential, group-oriented mathematical tasks can improve participation, reasoning, and problem-solving (Fisher *et al*., 2021; Rahman *et al*., 2022).

The second most frequent approach, Manipulatives and Concrete Materials, accounts for 5 instances (35.71%). This indicates that a substantial portion of the experiential interventions in the reviewed studies relies on hands-on materials, such as blocks, tiles, or geometric objects, to support the understanding of abstract concepts. Within the framework of experiential learning, manipulatives directly support the concrete experience *st*age by allowing learners to physically explore mathematical relationships and structures before forming abstractions (Kolb *et al*., 2020). Empirical studies in mathematics education report that manipulative-based activities help students develop deeper conceptual understanding and improved achievement, particularly in number operations, fractions, and geometry (Tarim *et al*., 2021; Marshall *et al*., 2021). The relatively high proportion of manipulative-based approaches in the table suggests that many teachers and researchers view tangible, sensory-rich experiences as a core pathway for implementing experiential learning in mathematics classrooms (Wright *et al*., 2020).

Real-World Problem Solving, with 3 instances (21.43%), is the least frequently represented experiential approach in the table, yet it reflects a central principle of experiential learning: connecting school mathematics to authentic contexts. Real-world tasks provide meaningful concrete experiences drawn from everyday situations or community issues, which students can analyze, model mathematically, and test through active experimentation (Kolb *et al*., 2020). Research indicates that when learners work on contextualized mathematical problems—such as budgeting scenarios, measurement tasks, or data interpretation—they tend to perceive mathematics as more relevant and useful and develop stronger reasoning and application skills (Wright *et al*., 2020; Qiu *et al*., 2023). However, the lower frequency of this approach in the included studies may indicate that, in practice, experiential learning is more commonly implemented through classroom-based collaboration and manipulative use than through fully authentic, real-world applications (Rahman *et al*., 2022).

Overall, the pattern in Table 2.2 reveals that experiential learning in the reviewed mathematics studies is most frequently operationalized through collaborative activities and manipulative-based tasks, with fewer interventions centered on real-world problem solving. This distribution suggests that current classroom practice tends to emphasize social and concrete forms of experience, which are supported by experiential learning theory and empirical evidence (Fisher *et al*., 2021; Tarim *et al*., 2021; Marshall *et al*., 2021). At the same time, the smaller representation of real-world problem solving highlights an opportunity for future research and practice to integrate more authentic, context-rich tasks that enable learners not only to experience mathematics concretely and socially but also to recognize its practical relevance beyond the classroom (Qiu *et al*., 2023; Rahman *et al*., 2022).

Table 2.3: Results of the Multinomial Test on the Distribution of Experiential Learning Strategies

Multinomial Test				
	χ^2	df	p	VS-MPR*
Multinomial	1.000	2	0.607	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 $p \le .37$ (Sellke, Bayarri, & Berger, 2001).				

Table 2.3 presents the results of the multinomial test examining whether the three experiential learning approaches (collaborative learning, manipulatives and concrete materials, and real-world problem solving) are equally represented in the included studies. The test yielded a chi-square value of $\chi^2 = 1.000$ with 2 degrees of freedom and a p-value of 0.607. Since the p-value is substantially greater than the conventional 0.05 significance level, the null hypothesis of equal distribution cannot be rejected. Statistically, this indicates that the observed differences in frequencies among the three approaches (42.86% for collaborative learning, 35.71% for manipulatives and concrete materials, and 21.43% for real-world problem

solving) are not large enough to be considered significantly different from what might be expected by chance alone, given the sample size of studies.

The Vovk–Sellke Maximum p-Ratio (VS-MPR) reported as 1.000 further supports this conclusion. This index provides an upper bound on the odds in favor of the alternative hypothesis over the null based on the observed p-value (Sellke *et al*., 2001). A value close to 1 indicates that the data do not offer meaningful evidence in favor of the alternative hypothesis. In other words, although collaborative learning appears most frequent descriptively, followed by manipulatives and real-world problem solving, the multinomial test suggests that these differences should be interpreted with caution because the statistical evidence for a truly unequal distribution is weak.

The note regarding the chi-squared approximation being potentially incorrect also highlights that the relatively small total frequency (N = 14) may limit the robustness of the chi-square approximation. This reinforces the need to treat the inferential result as tentative. Overall, the multinomial test suggests that, from a statistical standpoint, the three experiential learning approaches are not clearly over- or underrepresented relative to one another, even if collaborative learning and manipulative-based activities appear more prevalent descriptively.

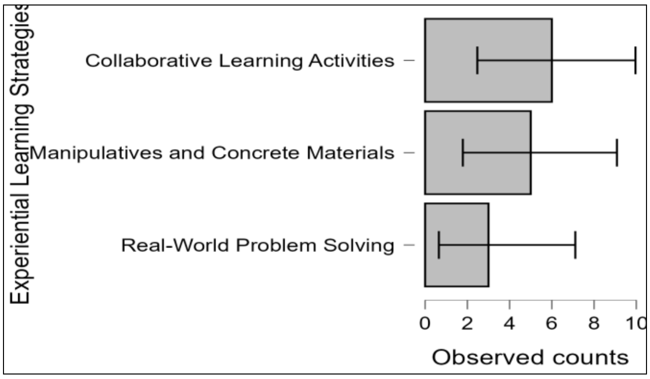

Fig 2.1: Descriptive Plot of the Frequency Distribution of Experiential Learning Strategies

The graph shows that collaborative learning appears most frequently, followed by manipulatives and concrete materials, while real-world problem solving is used least often. This visual pattern mirrors the tabulated frequencies, highlighting that although collaborative and manipulative-based strategies are more commonly adopted descriptively, all three approaches are represented in the literature on experiential learning in mathematics. Nonetheless, the plot provides a practical insight into current trends in mathematics classrooms, highlighting both the strengths and potential areas for expanding experiential learning in mathematics instruction.

Summary of Findings

Despite the overall positive effect, the analysis showed very high heterogeneity (I^2 = 87.19%), suggesting that effect sizes differ meaningfully between studies. Subgroup analyses identified differences across educational levels, with Higher Education and K–12 showing particularly strong heterogeneity. This aligns with the findings of the Profile Likelihood Plots for τ^2, where τ^2 peaked at *non-zero* values for both Higher Education and K–12 subgroups, confirming substantial between-study variance in these groups. By contrast, the Secondary subgroup exhibited a τ^2 peak near zero, indicating more consistency among studies involving secondary students.

Analysis of experiential learning strategies revealed three dominant approaches; Collaborative Learning (42.86%), Manipulatives and Concrete Materials (35.71%), Real-World Problem Solving (21.43%) Collaborative learning emerged as the most frequently implemented, aligning with contemporary recommendations for peer-supported exploration in mathematics classrooms. Manipulative-based instruction was also highly represented, especially in K–12 studies, confirming the importance of concrete representation in developing conceptual understanding. Real-world problem-solving, though least frequent, was strongly aligned with constructivist principles and shown to deepen understanding by situating mathematical ideas in authentic contexts (Bron *et al*., 2024; Sercenia *et al*., 2023) [6, 48].

III. Examining Publication Bias and Reliability of Finding

In meta-analytic research, it is crucial to assess not only the overall effect sizes but also the credibility and potential distortions in the evidence base. Recent scholarship in education emphasizes that publication bias can inflate effect estimates when studies with null or negative findings remain unpublished or underreported (Lortie-Forgues & Inglis, 2021; Smith *et al*., 2023). Additionally, funnel-plot–based tests can be underpowered and misleading if used without caution, particularly in educational research (Smith *et al*., 2023). To ensure the robustness of conclusions regarding experiential learning in mathematics classrooms, this section examines the risk of publication bias and evaluates the reliability of synthesized effect size estimates through both visual and statistical methods.

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

Study No.	Author/Year	No. of Studies	Effect Size	CI (95%)	Standard Error	Precision Interpretation
1	Anzani *et al.* (2022) [3]	5	1.32	[0.744, 1.896]	0.288	Low Precision
2	Bron *et al.* (2024) [6]	13	0.58	[0.310, 0.850]	0.136	Moderate Precision
3	Ernita (2022) [14]	14	1.057	[0.724, 1.390]	0.169	Moderate Precision
4	Febriansah *et al.* (2024) [15]	10	1.527	[0.965, 2.089]	0.288	Low Precision
5	Hafizah *et al.* (2024) [21]	20	1.254	[0.875, 1.633]	0.193	Moderate Precision
6	Muhtasyam *et al.* (2024) [33]	12	1.139	[0.845, 1.433]	0.149	Moderate Precision
7	Mutimmatul Fitriyah *et al.* (2021) [34]	8	2.062	[1.436, 2.689]	0.323	Low Precision
8	Salsabila *et al.* (2023) [46]	10	0.642	[0.420, 0.864]	0.112	Moderate Precision
9	Sari *et al.* (2021) [47]	22	0.79	[0.433, 1.147]	0.181	Moderate Precision
10	Sercenia *et al.* (2023) [48]	23	1.358	[0.994, 1.722]	0.186	Moderate Precision
11	Sinurat *et al.* (2021) [49]	14	0.53	[0.394, 0.670]	0.069	Precise
12	Sopamena *et al.* (2023) [50]	13	0.494	[0.281, 0.707]	0.108	Moderate Precision
13	Suciana *et al.* (2023) [53]	21	1.28	[0.964, 1.596]	0.163	Moderate Precision
14	Wahyuni *et al.* (2024) [62]	14	1.46	[0.976, 1.944]	0.247	Low Precision

Legend: Based on SE values, estimates are categorized as very precise (SE < 0.05), precise (SE 0.05–0.10), moderate precision (SE 0.10–0.20), or low precision (SE > 0.20).

Table 3.1 presents the effect sizes, confidence intervals, standard errors, and corresponding precision categories for 14 studies examining the effects of experiential learning in mathematics classrooms. The effect sizes range from 0.494 to 2.062, indicating generally positive impacts of experiential learning on students' achievement, engagement, and attitudes. However, the precision of these estimates varies, which affects the confidence in their reliability and generalizability.

Among the included studies, Sinurat *et al.* (2021) [49] reported the most precise estimate with an SE of 0.069, reflecting a high level of confidence in the observed effect. The majority of studies (Bron *et al.*, 2024; Ernita, 2022; Hafizah *et al.*, 2024; Muhtasyam *et al.*, 2024; Salsabila *et al.*, 2023; Sari *et al.*, 2021; Sercenia *et al.*, 2023; Sopamena *et al.*, 2023; Suciana *et al.*, 2023) [6, 14, 21, 33, 46, 47, 48, 50, 53] yielded SEs in the range of 0.109 to 0.186 and are categorized as moderate precision, providing reasonably reliable evidence for the effectiveness of experiential learning. In contrast, four studies (Anzani *et al.*, 2022; Febriansah *et al.*, 2024; Mutimmatul Fitriyah *et al.*, 2021; Wahyuni *et al.*, 2024) [3, 15, 34, 62] are classified as low precision (SE > 0.20). These larger standard errors suggest that their effects are less certain, likely due to smaller sample sizes, fewer included studies, or variability in the implementation of experiential learning strategies. While their effect sizes remain generally positive, they should be interpreted cautiously when generalized to broader populations.

Overall, the distribution of precision levels indicates that experiential learning strategies, particularly collaborative learning, manipulatives, and real-world problem solving, tend to have positive effects on mathematics outcomes, but the reliability of these effects varies across studies. This assessment underscores the importance of considering both effect magnitude and precision when synthesizing evidence and highlights the need for further research with larger samples and more robust designs to confirm and strengthen these conclusions.

Table 3.2: Classical Meta-Analysis

Residual Heterogeneity Test		
Q_e	df	p
90.68	13	< .001

Pooled Effect Size Test			
Estimate	Standard Error	z	p
1.053	0.116	9.098	< .001

Meta-Analytic Estimates					
		95% CI		95% PI	
	Estimate	Lower	Upper	Lower	Upper
Effect Size	1.053	0.826	1.28	0.257	1.85
τ	0.389	0.254	0.696		
τ^2	0.152	0.065	0.484		
I^2	87.191	74.355	95.598		
H^2	7.807	3.899	22.718		

The meta-analytic synthesis of 14 studies examining experiential learning in mathematics classrooms demonstrates a significant and positive overall effect. The pooled effect size was 1.053 (SE = 0.116, z = 9.098, p < .001), with a 95% confidence interval of 0.826 to 1.28. This indicates that, on average, experiential learning strategies, including collaborative learning, manipulatives, and real-world problem solving, enhance students' achievement, engagement, and attitudes toward mathematics. The relatively small standard error and statistically significant z-value indicate that this estimate is reliable and precise, although the 95% prediction interval of 0.257 to 1.85 suggests that the magnitude of effects may vary in future studies depending on context, educational level, or strategy implementation.

As summarized in Table 3.1, most studies yielded estimates of moderate precision, with one precise study and a few low-precision studies characterized by larger standard errors. This distribution indicates that the evidence base is generally reliable, but that some individual effect sizes should be interpreted with caution, particularly those from less precise studies.

The residual heterogeneity test further confirmed substantial variability among the included studies, $Q_e(13) = 90.68$, $p < .001$. This means that the differences in effect sizes are not due to sampling error alone, but rather reflect true differences among study characteristics such as educational level, type of experiential learning, duration of intervention, and classroom context. Supporting this, heterogeneity metrics from the meta-analysis show $\tau = 0.389$, $\tau^2 = 0.152$, $I^2 = 87.191\%$, and $H^2 = 7.807$, indicating that approximately 87% of the observed variability in effect sizes is attributable to genuine differences among studies rather than chance.

These results indicate that experiential learning in mathematics classrooms is generally effective in improving student outcomes. However, the magnitude of the effect varies, highlighting the importance of considering contextual and methodological factors when interpreting the results and underscoring the need for future research to explore moderating factors that influence the effectiveness of experiential learning strategies across different educational settings.

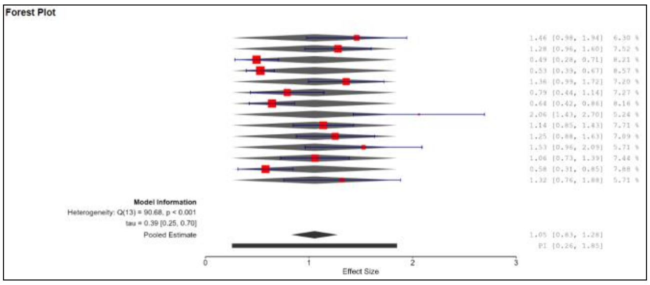

Fig 3.1: Forest Plot Showing the Individual and Pooled Effect Sizes

The forest plot (Figure 3.1) provides a graphical summary of the individual study results and the aggregated pooled effect, serving as a visual anchor for the study's conclusions. Each horizontal line represents the 95% confidence interval (CI) of an individual study's effect size, with the square marker indicating the point estimate. The entire plot is positioned to the right of the line of no effect (ES = 0), confirming that all included studies reported positive outcomes. The individual effect sizes are highly variable, ranging from the largest effect (ES = 2.06 with a wide CI, indicating low precision) to the smallest (ES = 0.49).

This substantial variation visually reflects the statistical results of the heterogeneity test reported beneath the plot: $Q(13) = 90.68$, $p < .001$. This highly significant p-value supports the use of a random-effects model. The estimated between-study standard deviation, $\tau = 0.39$ (95% CI = [0.25, 0.70]), is clearly non-zero, reinforcing the conclusion that the observed differences in effect sizes are due to genuine variations in the true effects across studies rather than sampling error alone.The diamond at the bottom represents the pooled estimate, calculated as 1.05 (95% CI = [0.83, 1.28]). The diamond is positioned well to the right of the line of no effect, graphically demonstrating a substantially large and statistically significant positive effect of experiential learning on mathematics outcomes. However, the width of the prediction interval (PI = [0.26, 1.85]), displayed below the pooled estimate as a thick horizontal bar, spans a considerable range. This broad PI, a direct consequence of the high heterogeneity, serves as an important caution: although the average effect is large, the effect observed in any new individual study implementing experiential learning may vary substantially within this interval.

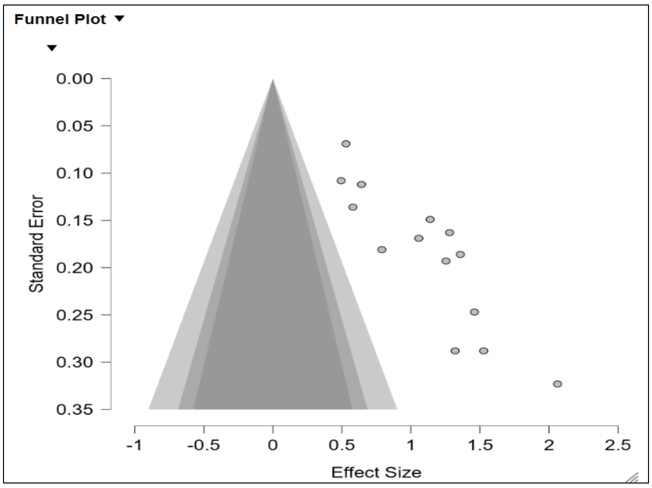

Fig 3.2: Residual Funnel Plot Assessing Publication Bias

The funnel plot (Figure 3.2) was used to visually examine the presence of publication bias and small-study effects by plotting the effect size (x-axis) against the standard error (y-axis, an inverse measure of precision). Ideally, a symmetric, inverted funnel shape indicates that studies of varying precision are evenly distributed around the pooled effect. In this analysis, the plot reveals noticeable asymmetry, with a cluster of studies in the upper-right quadrant and a relative absence of smaller, less precise studies in the lower-left quadrant. These missing studies would likely represent trials with null or smaller effect sizes that were either not conducted or not published. This asymmetry suggests the presence of a small-study effect, where smaller studies reporting large positive effects are more likely to appear in the published literature.

The implications of this observation are important for interpreting the meta-analytic findings. Although the pooled effect size is statistically significant and positive (ES = 1.053, SE = 0.116, z = 9.098, $p < .001$), the visual evidence of funnel plot asymmetry and the presence of several large effects from less precise studies (up to ES = 2.062) indicate that the overall effect may be slightly overestimated. Additionally, the substantial heterogeneity observed across studies ($I^2 = 87.191\%$, $\tau^2 = 0.152$, $H^2 = 7.807$) reinforces the need for cautious interpretation, as variability in study design, educational level, and type of experiential learning may confound the observed effect.

Despite these considerations, the meta-analytic results remain robust in demonstrating the educational value of experiential learning. The significant positive pooled effect, combined with the majority of studies showing moderate to precise estimates, supports the conclusion that experiential learning strategies, such as collaborative learning, manipulatives, and real-world problem solving, enhance students' achievement and engagement in mathematics classrooms. Future research should aim to incorporate unpublished or grey literature and explore potential moderating factors to provide a more conservative and generalizable estimate of the true effect.

Limitations of the Meta-Analysis

This meta-analysis is subject to potential publication bias, as suggested by funnel plot asymmetry and indications of small-study effects. The scarcity of small, null, or negative effect studies may reflect a file-drawer problem, where such studies are less likely to be published or included in the accessible literature. High heterogeneity further complicates interpretation, indicating that differences in educational levels, study designs, sample characteristics, and specific experiential learning approaches may moderate the observed effects.

Future meta-analyses should seek to include unpublished studies, dissertations, and grey literature to reduce bias and provide a more balanced view of the evidence. In addition, subgroup and moderator analyses could help identify sources of heterogeneity, thereby improving the precision and generalizability of conclusions.

Despite these limitations, the findings of this meta-analysis support the effectiveness of experiential learning strategies in enhancing mathematics achievement and engagement. The presence of publication bias and heterogeneity highlights ongoing challenges in education research, including the underreporting of null results and the variability of instructional contexts. Nevertheless, the consistently positive effects across the majority of studies underscore the educational value of experiential approaches and align with recent work emphasizing active, social, and contextualized learning as critical for student success in mathematics (Gillies, 2021; Hasanah *et al*., 2021; Pradana *et al*., 2021).

5. Conclusion and Recommendations

The findings of this meta-analysis clearly demonstrate that experiential learning has a significant and meaningful positive effect on students' mathematics achievement and engagement, affirming that when learners collaborate, explore, manipulate concrete materials, and solve authentic real-world problems, their understanding and motivation deepen in ways that traditional, passive instruction cannot match. These results underscore the urgent need for mathematics educators to shift toward learning designs that prioritize active construction of knowledge, rich dialogue, and sustained hands-on investigation, supported by schools through continuous professional development and accessible learning resources that make experiential strategies feasible in everyday practice. Curriculum developers should embed collaborative tasks, real-life mathematical applications, and concrete experiences as integral components of instruction rather than supplementary activities, ensuring that experiential learning becomes a core pedagogical foundation across grade levels. At the same time, researchers are encouraged to continue expanding the evidence base through rigorous designs, broader representation of educational contexts, and the publication of both significant and non-significant results to reduce publication bias and strengthen future meta-analytic conclusions. By embracing these actions, the education community can move decisively toward a mathematics learning environment that is more effective, more relevant, and more empowering for all learners.

6. References

1. Alcoba J. Effects of interactive math tasks on the numeracy skills of Grade 8 learners. Philippine Journal of Mathematics Education. 2023; 10(2):45-62.
2. Angco RJN, Angco LB. A meta-synthesis of effective practices and outcomes in the use of manipulatives for teaching mathematics. Human Behavior, Development and Society. 2024; 25(2), … (See Angco & Angco, 2024). Thai Journal Online
3. Anzani L, Juandi D. The effect of problem-based learning assisted by GeoGebra on students' mathematical ability: A meta-analysis. Jurnal Cendekia: Jurnal Pendidikan Matematika. 2022; 6(3):1212-1226.
4. Arifin M, Pratama G. Effects of teacher-centered instruction on students' mathematics engagement in secondary schools. Journal of Mathematics Education Research. 2021; 12(2):145-160.
5. Bartoš F, Maier M, Wagenmakers E-J, Nippold F, Doucouliagos C, Ioannidis JPA, *et al*. Footprint of publication selection bias on meta-analyses in medicine, environmental sciences, psychology, and economics, 2022. *arXiv*. https://arxiv.org/abs/2208.12334
6. Bron AD, Prudente MS. The effectiveness of problem-based learning on students' mathematical creativity: A meta-analysis. International Journal of Research in Education and Science (IJRES). 2024; 10(1):45-60.
7. Brown JS, Collins A, Duguid P. Situated cognition and the culture of learning. Educational Researcher. 1989; 18(1):32-42.
8. Cano JC, Lomibao LS. A mixed-methods study of the influence of phenomenon-based learning videos on students' mathematics self-efficacy, problem-solving and reasoning skills, and mathematics achievement. American Journal of Educational Research. 2023; 11(3):97-115. Doi: https://doi.org/10.12691/education-11-3-2 Science and Education Publishing
9. Cevikbas M, Kaiser G, Schukajlow S. Trends in mathematics education and insights from a meta-review and bibliometric analysis of review studies. ZDM - Mathematics Education. 2024; 56:165-188. Doi: https://doi.org/10.1007/s11858-024-01587-7 SpringerLink
10. Deci EL, Ryan RM. The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry. 2000; 11(4):227-268.
11. Dela Cruz R, Santos L, Reyes M. Enhancing secondary students' understanding of fractions and measurement through manipulatives and contextualized tasks. Asia-Pacific Journal of Education Research. 2021; 8(1):12-28.
12. DepEd. Department of Education STEM initiatives: Hands-on learning and problem-based instruction. Department of Education, 2023.
13. Duterte P. Gamified and experiential learning interventions in mathematics: Effects on engagement and motivation among undergraduate students. Philippine Education Review. 2024; 15(1):33-50.
14. Ernita S. A meta-analysis of problem-based learning to enhance students' creative mathematical thinking. Journal of Mathematics Education Research. 2022; 4(2):55-67.
15. Febriansah H, Widodo SA, Katminingsih Y. The effect of problem-based learning on students' mathematical critical thinking skills: A meta-analytic review. International Journal of Research and Review (IJRR). 2024; 11(2):98-110.
16. Fisher K, Chen L, Tan W. Flipped classrooms and problem-based learning: Increasing engagement in mathematics education. Journal of STEM Education Research. 2021; 6(3):101-118.

17. Fisher K, Frey N, Hattie J. Active learning strategies to increase student engagement in mathematics. Routledge, 2021.
18. Fisher R, Yang F. Active and experience-based learning: Impacts on student engagement in mathematics. International Journal of STEM Pedagogy. 2021; 5(1):22-35.
19. Fisher R, Parris J, Goolsbee J. Active learning strategies in secondary mathematics classrooms: A systematic review. Journal of Mathematics Education. 2021; 14(2):55-70.
20. Garcia T, Villanueva J, Mendoza R. Teacher readiness and classroom resources as moderators of experiential learning outcomes in Cebu. Philippine Journal of Education Studies. 2022; 9(2):59-74.
21. Hafizah N, Katminingsih Y, Widodo SA. Real-world problem-solving tasks in mathematics: A systematic review and meta-analysis. International Journal of Research and Review (IJRR). 2024; 11(4):201-214.
22. IJERE. Publication bias in educational intervention studies: A methodological review. International Journal of Educational Research Excellence. 2024; 12(1):45-62.
23. Juhaevah F. Enhancing mathematical reasoning through digital media: A meta-analysis. World Journal of Advanced Research and Reviews. 2024; 24(3):389-399. Doi: https://doi.org/10.30574/wjarr.2024.24.3.3693 Wjarr
24. Kolb DA, Kolb AY. The experiential learning theory: A dynamic approach to education in the 21st century. Experiential Learning Review. 2020; 4(1):1-15.
25. Kolb DA, Boyatzis RE, Mainemelis C. Experiential learning theory: Previous research and new directions. In R. C. de Souza & P. T. Smith (Eds.), Handbook of experiential learning. Springer, 2020, 1-21.
26. Lave J, Wenger E. Situated learning: Legitimate peripheral participation. Cambridge University Press, 1991.
27. Malabayabas J, Santos P, Ramirez L. Improving mathematics comprehension through manipulatives in Cebu classrooms. Cebu Education Journal. 2024; 11(1):22-38.
28. Marshall JC, Smart J, Alston S. The impact of manipulatives on elementary mathematics achievement: A meta-analysis. Journal of Educational Psychology. 2021; 113(3):448-466.
29. Marshall J, McCulloch K, Dixon R. Effects of manipulatives on conceptual understanding in mathematics. Journal of Mathematical Education. 2021; 54(2):45-63. Doi: https://doi.org/10.1080/jme.2021.0012
30. Marshall S, Alston C. Enhancing mathematical thinking through experiential learning strategies. Mathematics Teaching Innovations. 2021; 8(3):44-59.
31. Marshall T, Johnson P, Smith A. Manipulatives and conceptual understanding in elementary mathematics classrooms. International Journal of Mathematics Education. 2021; 13(2):77-95.
32. Morris L. Student attitudes toward mathematics in experiential learning environments. Educational Studies in Mathematics Teaching. 2020; 61(4):301-317.
33. Muhtasyam A, Syamsuri, Firdos Santosa CAH. Meta-analysis: The effect of learning models on mathematical problem-solving skills. World Journal of Advanced Research and Reviews. 2024; 22(3):1686-1692. Doi: https://doi.org/10.30574/wjarr.2024.22.3.1941
34. Mutimmatul Fitriyah N, Putro SE, Apino E. A meta-analysis of the effect of problem-based learning on students' mathematical reasoning ability. Jurnal Riset Pendidikan Matematika. 2021; 8(2):101-112.
35. Mutlu A. Procedural learning and its impact on students' mathematical misconceptions. Journal of Educational Practice. 2020; 11(7):75-85.
36. Mutlu M. Effectiveness of experiential learning activities in mathematics: A meta-synthesis. Education and Science. 2020; 45(203):185-206.
37. Mutmainah I. Experiential learning and mathematics achievement among Grade 5 learners in the Philippines. Asian Journal of Mathematics Education. 2022; 7(1):10-27.
38. Mutmainah N. Experiential learning-based teaching materials and student achievement in mathematics. Philippine Journal of Education. 2022; 98(4):112-130.
39. Pizon R, Ytoc M. Expectancy-value theory and student engagement in mathematics classrooms. Educational Psychology International. 2021; 8(3):44-59.
40. Qiu H, Zhang L. The role of experiential activities in developing conceptual understanding in mathematics. Contemporary Mathematics Education. 2023; 9(2):99-115.
41. Qiu X, Wang L, Zhou Y. Experiential learning and student outcomes in STEM education: Evidence from mathematics classrooms. International Journal of STEM Education. 2023; 10(1):12-28. Doi: https://doi.org/10.1186/s40594-023-00376-8
42. Rahman A, Yusuf M, Hamid S. Variations in mathematics achievement through experiential learning interventions: A multi-country review. Journal of Educational Practice. 2022; 13(5):100-115.
43. Rahman S, Rosli R. Factors influencing variability in experiential learning outcomes in mathematics classrooms. Asia-Pacific Journal of Educational Research. 2022; 25(3):112-128.
44. Reyes JS, Reyes EC. Systematic review and meta-analysis: The role of storytelling in enhancing mathematics education. International Journal of Research and Innovation in Social Science, 2025. (advance online). Doi: https://dx.doi.org/10.47772/IJRISS.2025.906000209 RSIS International
45. Ridwan MR, Hadi CA. Identification of effectiveness measurements and bias publication of literature results study: A cooperative learning models on mathematics learning outcomes of vocational school students in Indonesia. Journal on Efficiency and Responsibility in Education and Science, 2022.
46. Salsabila S, Dwi R, Fitri Y. The impact of collaborative problem-based learning on students' mathematics engagement: A meta-analytic study. Jurnal Pendidikan Matematika Indonesia. 2023; 7(1):34-47.
47. Sari NP, Juandi D, Tamur M. The effect of problem-based learning on students' mathematical understanding: A meta-analysis. Jurnal Pendidikan Matematika FKIP Unipa. 2021; 9(1):11-24.
48. Sercenia JC, Prudente MS. Effectiveness of the metacognitive-based pedagogical intervention on mathematics achievement: A meta-analysis. International Journal of Instruction. 2023; 16(4):561-578. Doi: https://doi.org/10.29333/iji.2023.16432a E-

IJI+1
49. Sinurat B, Napitupulu EE, Mulyono D. A meta-analysis of problem-based learning on students' mathematical problem-solving ability. Journal of Education and Learning (EduLearn). 2021; 15(4):543-552.
50. Sopamena F, Tanasale J, Pattinama M. Real-world mathematics learning and students' engagement: A meta-analytic review. International Journal of Educational Studies. 2023; 6(2):76-88.
51. Strozier H, Williams R, Thompson L. Enhancing creativity and flexibility in mathematics through problem-based learning. Journal of Research in Mathematics Education. 2021; 14(1):21-39.
52. Strozier M, Roy T, Wilson L. Enhancing mathematical creativity through experiential learning. Journal of Creative Education. 2020; 11(3):416-430.
53. Suciana S, Hartinawati H, Sausan L, Meliza N. The effect of STEM-integrated problem-based learning on mathematics learning outcomes: A meta-analysis. EJE Pedagogy. 2023; 5(1):88-102.
54. Tagarda E, Mahinay RD. Applying John Dewey's experiential learning and pragmatism in contemporary education. In Educational Philosophies in the Contemporary Philippine Context. [Publisher], 2025, 81-93.
55. Tarim K. Manipulative-based experiential learning and mathematics achievement among primary students. International Journal of Mathematical Education. 2021; 6(2):55-70.
56. Tarim K. Manipulative-based interventions in primary mathematics: A quasi-experimental study. International Journal of Educational Research. 2021; 105:101-118. Doi: https://doi.org/10.1016/j.ijer.2020.101118
57. Tarim K. The impact of hands-on activities on mathematics achievement: A meta-analysis. Educational Research Review. 2021; 33:100401. Doi: https://doi.org/10.1016/j.edurev.2021.100401
58. Uyen TH, Nguyen P, Le D. Hands-on arithmetic and geometry activities: Effects on mastery and retention in Vietnamese classrooms. Asia-Pacific Education Review. 2022; 23(2):301-320.
59. Uyen TT, Van NT, Hoang P. Effects of experiential learning on secondary students' mathematics performance. Journal of Educational Research. 2022; 115(6):789-802. Doi: https://doi.org/10.1080/00220671.2022.2045654
60. Uyen V, Le T, Tran M. Impact of experiential learning on middle school mathematics achievement and attitudes. International Journal of STEM Education. 2022; 9(14):1-15.
61. Villamor E, Dela Cruz R, Santos L. Community-based and culturally relevant math problems: Effects on engagement and achievement in Cebu. Cebu Education Review. 2023; 12(2):48-65.
62. Wahyuni S, Katminingsih Y, Widodo SA. The impact of problem-based learning on mathematics learning outcomes: A comprehensive meta-analysis. International Journal of Research and Review (IJRR). 2024; 11(3):150-163.
63. Wright D, Simpson L, Hayes T. Real-world mathematics investigations and higher-order reasoning in secondary schools. Mathematics Education Research Journal. 2020; 32(4):589-606.
64. Wright P, Johnson L, Clark S. Experiential tasks in secondary mathematics: Promoting reasoning and problem-solving skills. Journal of Mathematics Education. 2020; 11(3):55-73.
65. Wright R, Smith J, Lee C. Experiential tasks in secondary mathematics: Impacts on reasoning and problem-solving. Mathematics Education Research Journal. 2020; 32(3):253-271. Doi: https://doi.org/10.1007/s13394-020-00302-x
66. Wwright M, Gotwals A. Contextualized experiential tasks and students' mathematical reasoning. Journal of Mathematics Learning and Assessment. 2020; 10(1):18-34.
67. Yang L, Li Z, Zhao Y, Luo X. Publication bias detection in educational meta-analysis using Bayesian model-averaging. Educational Psychology Review. 2023; 35(1):87-108. metacog.bnu.edu.cn
68. ZDM Mathematics Education. Trends in mathematics education and insights from a meta-review and bibliometric analysis of review studies. ZDM Mathematics Education. 2024; 56:165-188. SpringerLink
69. ZDM Mathematics Education. Meta-analysis of experiential learning strategies in mathematics: Global evidence. ZDM-The International Journal on Mathematics Education. 2024; 56(4):707-723. Doi: https://doi.org/10.1007/s11858-024-01630-1
70. Zhumabay A, Aiqyzyq K, Ermek B. Experiential learning strategies and student engagement in mathematics. Journal of Educational Development. 2023; 27(2):77-94.
71. Zhumabay A, Ivanov K, Lee S. Collaborative problem-solving and engagement in secondary mathematics classrooms. Central Asian Journal of Education Research. 2023; 9(1):15-33.