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EFFECT OF MNEMONIC STRATEGIES ON VOCABULARY MASTERY AND READING LITERACY: A META-ANALYSIS

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Abstract: Literacy is a fundamental educational element that extends beyond decoding written symbols to include understanding, using, and reflecting on information, with vocabulary mastery playing a critical role in supporting reading comprehension and overall academic success. This meta-analysis aims to quantitatively synthesize existing research on the effectiveness of mnemonic strategies in enhancing vocabulary acquisition and reading literacy, while also exploring moderating factors that influence these outcomes to provide evidence-based guidance for educational practice. This study employed a rigorous quantitative meta-analytic design using a random-effects model to synthesize effect sizes from 35 empirical studies across various educational levels, examining the direct and mediated effects of mnemonic strategies on vocabulary mastery and reading literacy, while ensuring reliability through a systematic review process, transforming diverse statistical data into standardized effect sizes, addressing heterogeneity and publication bias, and exploring moderator variables through sensitivity and subgroup analyses to provide comprehensive and generalizable insights into the effectiveness of mnemonic instruction. The meta-analysis revealed a significant pooled effect size of 0.81 (95% CI: 0.79 to 0.84) for mnemonic strategies on vocabulary mastery and reading literacy, alongside a significant heterogeneity ($Q(34) = 49.47$, $p = 0.042$), indicating variability in effectiveness across studies likely influenced by moderating factors such as learner characteristics and instructional context. Despite this variability, the relatively low heterogeneity ($\tau = 0.04$) and robust model fit (AIC and BIC values) suggest that mnemonic strategies generally produce strong and consistent positive effects on literacy outcomes across diverse educational settings.
Keywords: *mnemonic strategies; vocabulary mastery; reading literacy.*

INTRODUCTION

Literacy has long been recognized as a foundational element in education, serving not only as a gateway to academic success but also as a means for individuals to engage meaningfully with their social environment (Lebert & Vilarroya, 2024). In modern educational contexts, literacy is no longer viewed merely as the ability to decode written symbols; rather, it encompasses a broader capacity to understand, utilize, and reflect upon written information (Beach et al., 2025). This multidimensional perspective positions literacy as a critical tool for personal development, lifelong learning, and effective participation in the knowledge-based society of the twenty-first century.

Reading literacy, specifically, is increasingly seen as a central component of educational competence, as it shapes the ways students interact with academic content across disciplines (Chee et al., 2025). Through reading, learners access new ideas, reinforce prior knowledge, and develop analytical and reflective thinking skills (Hidayad et al., 2024). Without strong literacy foundations, students often face difficulties comprehending texts, which in turn limits their performance in other subject areas. Therefore, strengthening literacy from early education onward is essential for cultivating well-rounded, capable learners.

Within the broader realm of literacy, vocabulary mastery plays a uniquely important role. Vocabulary functions as the building blocks of comprehension, enabling readers to process meaning efficiently and accurately (Lensun et al.,

2025). When students possess a rich repertoire of words, they are better equipped to infer meaning, engage with complex texts, and express ideas effectively. Conversely, limited vocabulary is widely acknowledged as one of the most persistent barriers to reading comprehension, often contributing to gaps in academic achievement (Keysan, 2024).

Many students struggle with learning and retaining new vocabulary, especially when they are required to memorize extensive lists of unfamiliar terms (Chung & Newton, 2025). Traditional approaches that rely heavily on rote memorization can be ineffective, monotonous, and discouraging. As a result, learners may disengage, leading to superficial understanding or quick forgetting of the words they have studied (Peng et al., 2025). This challenge highlights the need for more engaging and cognitively supportive approaches to vocabulary acquisition.

Given the complexity of mastering vocabulary, educators and researchers have emphasized the importance of adopting effective learning strategies (Dan et al., 2025). Contemporary pedagogical thinking advocates for instructional methods that not only deliver content but also empower students to regulate their own learning processes (Dwikamayuda, 2024). In this context, innovative techniques that promote deeper cognitive engagement have become increasingly relevant, particularly for tasks that demand long-term retention such as vocabulary learning (Bugti & Iqbal, 2024).

One strategy that has gained considerable attention is the use of mnemonic techniques. Mnemonic strategies are specialized tools designed to enhance memory by linking new information to familiar concepts, images, or associations (Jantakoon et al., 2025). These techniques leverage how the human brain naturally processes and stores information, making learning more efficient and memorable (Henry et al., 2025). Examples include the Keyword Method, the Peg-Word Method, and the Method of Loci, all of which transform abstract vocabulary items into vivid and meaningful mental representations.

The theoretical foundation of mnemonic strategies lies in the idea that memory improves when information is encoded in multiple ways, such as through imagery, semantic connection, or contextual cues (Cooper et al., 2024). Instead of relying solely on repetition, learners use creative associations that facilitate deeper processing and more durable recall. For vocabulary learning, this approach is particularly suitable, as many words can be paired with visual or conceptual cues that make them easier to retrieve later (Olivete et al., n.d.).

Early research on mnemonic strategies has offered promising evidence regarding their effectiveness in vocabulary learning contexts (Haryadi & Sunarsi, 2024). Several experimental studies have reported significant improvements in students' ability to recall and understand new vocabulary when mnemonics are used (Soares et al., 2025). Learners also tend to express positive attitudes toward these techniques, noting that they find them more engaging and enjoyable compared to traditional memorization methods.

However, despite these encouraging findings, the broader research landscape reveals inconsistencies that raise important questions (Querol-Cintron, 2025). Not all studies have shown equally strong effects; some have reported minimal improvements or outcomes that do not reach statistical significance. These variations suggest that the effectiveness of mnemonic strategies may depend on specific contextual or methodological factors that warrant systematic investigation (Qu et al., 2024).

One potential source of variability lies in differences across educational levels. Mnemonics may be more effective for younger learners who benefit from visual and imaginative techniques, while older students might rely more on analytical strategies (Grünke et al., 2024). Alternatively, the reverse might be true depending on the complexity of the vocabulary or the instructional setting (Rosalina & Salam, 2024). Understanding these nuances is essential for determining when and for whom mnemonic strategies work best.

The type of mnemonic strategy employed may also contribute to inconsistent findings (De Vito et al., 2025). For example, the Keyword Method involves creating semantic or phonological links between familiar and unfamiliar words, whereas the Method of Loci requires constructing spatial memory pathways (Dan et al., 2025). These strategies may differ in cognitive demand, suitability for different learning styles, and compatibility with specific vocabulary types. Such distinctions highlight the need for comparative evaluation.

Another factor that may influence the effectiveness of mnemonic strategies is the linguistic context in which they are used. Vocabulary learning in a first language (L1) environment may differ considerably from learning in a second or foreign language (L2) (Kapnoula & Samuel, 2024). L2 learners often face additional

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challenges, such as unfamiliar phonological patterns or limited background knowledge, which may affect how easily they can create meaningful associations (Zajda, 2024).

Given these inconsistencies and potential moderating factors, a more comprehensive and quantitative approach is required to synthesize the existing evidence (Wu et al., 2025). A meta-analysis provides an ideal methodological framework for integrating findings from multiple studies, calculating overall effect sizes, and identifying patterns across varied contexts (Komalawardhana et al., 2021). Unlike narrative reviews, which may be selective or subjective, meta-analyses provide statistically grounded conclusions that reflect the collective weight of available research.

Conducting a meta-analysis is especially important in this field because individual studies often involve small sample sizes or specific instructional settings that limit their generalizability (Udaya & Reddy, 2024). By pooling data, researchers can overcome these limitations and obtain more reliable estimates of the true effect of mnemonic strategies. Such evidence can support educators, policymakers, and curriculum developers in making informed decisions about instructional design (Harris, 2024).

In addition to evaluating the impact of mnemonic strategies on vocabulary learning, this research also aims to examine their potential effect on broader reading literacy outcomes. The relationship between vocabulary knowledge and reading comprehension is well established, with researchers consistently identifying vocabulary as one of the strongest predictors of reading success (Salas et al., 2025). Therefore, it is reasonable to hypothesize that improvements in vocabulary resulting from mnemonic instruction may transfer to enhanced reading performance.

Nonetheless, the extent to which such transfer occurs remains uncertain. While some studies have reported that mnemonic-based vocabulary gains translate into better comprehension scores, others have found limited or no transfer effects (Mekuria et al., 2024). This discrepancy underscores the importance of examining literacy outcomes alongside vocabulary outcomes to gain a fuller understanding of the instructional value of mnemonic strategies (Murphy & Arciuli, 2024).

Focusing simultaneously on vocabulary mastery and reading literacy provides a more holistic view of how mnemonic instruction supports learners. Vocabulary development is not an isolated goal; it forms part of a larger system of language and literacy skills (Wood et al., 2025). Understanding how mnemonic strategies influence this system can yield deeper insights into how these techniques should be implemented in educational practice.

In articulating the aims of this meta-analysis, the primary objective is to determine the aggregated effect of mnemonic strategies on student vocabulary acquisition (Sridevi et al., 2024). This includes assessing both short-term recall and long-term retention, as both dimensions are crucial for meaningful vocabulary mastery. The meta-analysis seeks to provide a clear, statistically robust estimate of how effective mnemonic strategies truly are across diverse learning environments.

A second major objective is to evaluate the overall effect of mnemonic strategies on reading literacy. By synthesizing evidence across studies, the research aims to clarify whether mnemonic-based vocabulary instruction yields measurable improvements in comprehension and other literacy-related skills (Cheng et al., 2025). This component addresses an important gap in the literature and provides a more comprehensive perspective on instructional effectiveness.

A third important aim is to identify and analyze moderator variables that may influence the impact of mnemonic strategies. These moderators may include the type of mnemonic strategy used, the educational level of participants, the linguistic environment, the duration of instruction, or methodological characteristics of the studies. Examining these variables can help explain inconsistencies in findings and guide the development of more tailored instructional approaches (Faradiba et al., 2024).

Through these objectives, the meta-analysis aspires to contribute both theoretical and practical insights to the field of vocabulary instruction. From a theoretical perspective, the research helps refine understanding of how mnemonic strategies function within cognitive learning frameworks. From a practical perspective, it offers evidence-based recommendations that can enhance teaching effectiveness across educational contexts.

This narrative establishes the need for a systematic, quantitative synthesis of existing research on mnemonic strategies in vocabulary and literacy instruction. By integrating diverse findings and identifying key patterns, the meta-analysis aims to provide clear guidance for educators seeking to implement effective and engaging vocabulary teaching methods. The results are expected to inform future research directions and

support the ongoing pursuit of literacy improvement in modern education.

METHOD

This study employed a quantitative meta-analytic design utilizing a random-effects model to synthesize and analyze heterogeneous effect sizes from multiple primary studies. The analysis focused on two main paths: the direct effect of mnemonic strategies on vocabulary mastery, and the subsequent impact of vocabulary mastery on reading literacy. These pathways were further integrated into a meta-analytic mediation framework to assess whether improvements in vocabulary mastery mediate the effects of mnemonic instruction on students' reading literacy. This methodological approach allowed for a rigorous evaluation of the overall effectiveness of mnemonic strategies and the mechanisms underlying their influence on literacy outcomes.

The meta-analysis incorporated a comprehensive systematic review process consisting of four stages: identification, screening, eligibility assessment, and inclusion. Two independent coders conducted the review to ensure reliability and minimize bias, achieving a high inter-rater agreement (Cohen's $\kappa = 0.86$). The final sample included 35 empirical studies that met strict eligibility criteria, which required the studies to involve student populations across various educational levels—elementary, middle, high school, and tertiary education. Included studies also had to employ quantitative research designs or provide extractable quantitative data suitable for effect-size computation.

Eligibility criteria mandated that studies report sufficient statistical information such as means and standard deviations, correlations, or other inferential statistics convertible into standardized effect sizes (Hedges's g or Pearson's r). Discrepancies in study inclusion or data extraction were resolved through consensus discussions between the coders. This rigorous selection ensured that the meta-analysis synthesized reliable and comparable effect sizes to represent the influence of mnemonic strategies on vocabulary and reading outcomes comprehensively.

Statistical analyses were conducted using Comprehensive Meta-Analysis (CMA) software version 3. Effect sizes for between-group comparisons were calculated as Hedges's g, while correlational relationships were expressed using Pearson's r. Where necessary, statistical results such as t-values, F-values, or regression coefficients were transformed to standardized effect sizes. The random-effects model was chosen to account for between-study variability, which was confirmed by heterogeneity statistics (Q-test, I^2, and τ^2). The estimated heterogeneity ($I^2 \approx 52.7\%$) indicated moderate variability, justifying the use of this model to produce more generalizable results across diverse study conditions.

Further analyses examined the mediation effect of vocabulary mastery on reading literacy using CMA's mediation procedure, estimating both direct and indirect effects of mnemonic strategies on literacy outcomes. The robustness of the meta-analytic findings was supported by publication bias assessments, including funnel plot inspections, Egger's regression tests, and the Trim-and-Fill method. Sensitivity analyses, such as leave-one-out diagnostics, evaluated the influence of individual studies on pooled effects. Additionally, subgroup analyses explored potential moderators, including educational level and mnemonic strategy type, to explain variability in effectiveness. Results were summarized in forest plots and tables detailing pooled effect sizes, confidence intervals, and heterogeneity indices, providing a comprehensive view of the evidence base.

RESULTS AND DISCUSSION

Reliability of the synthesized evidence and consistency across included studies

The synthesized evidence obtained from the selected studies demonstrates a clear and consistent pattern regarding the effectiveness of mnemonic strategies on vocabulary mastery. After the initial identification of a broad pool of research, only studies meeting strict inclusion standards remained, resulting in a refined dataset that reflects reliable and well-documented findings. This rigorous filtering process helps ensure that the conclusions drawn from the meta-analysis are grounded in credible evidence rather than anecdotal or methodologically weak sources. Through careful evaluation, the surviving studies presented coherent patterns that strengthen confidence in the aggregated effect sizes. Such systematic refinement ultimately enhances the trustworthiness of the overall conclusions.

A careful examination of the included studies reveals that many employed robust experimental or quasi-experimental designs, contributing to the reliability of synthesized results. These designs typically featured clear intervention procedures, consistent vocabulary targets, and well-defined instructional treatments. As a result, the effect sizes produced by these studies carry a degree of methodological soundness that strengthens the

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aggregated findings. While some methodological variability remained, the overall quality ensured that outcomes were not heavily influenced by flawed or incomplete research practices. The consistency in experimental design across studies also allowed for meaningful comparisons and more stable meta- analytic calculations.

Another aspect contributing to reliability is the transparency in reporting statistical measures across the included studies. Many provided sufficient data on means, standard deviations, sample sizes, or post-test comparisons, which allowed for accurate calculation of standardized effect sizes. This transparency is essential in meta-analysis, as incomplete or ambiguous reporting can distort aggregated results. The presence of detailed statistical information made the synthesis process more precise and minimized the likelihood of computational errors. This clarity in reporting not only strengthened the dataset but also enhanced the interpretability of the final outcomes.

The refined set of studies also showed consistency in the direction of effects, with nearly all reporting positive benefits of mnemonic strategies on vocabulary mastery. Even though the magnitude of improvement varied, the unified direction increases confidence that mnemonics reliably contribute to vocabulary development across diverse educational contexts. Such convergence across multiple independent investigations suggests that the observed effects are not isolated or coincidental. Instead, they likely reflect a genuine instructional advantage that persists across differing populations, languages, and instructional settings. This consistency is a hallmark of reliable evidence in educational research.

A notable strength in the evidence synthesis lies in the repeated documentation of benefits across studies conducted in varied geographical regions and linguistic backgrounds. The presence of consistent outcomes—whether in first-language or second-language learning contexts—suggests that mnemonic strategies have a broad and adaptable range of applicability. This cross-contextual consistency contributes significantly to the external validity of the meta-analytic findings. It highlights that the underlying cognitive mechanisms supporting mnemonic use remain stable across cultural and linguistic differences. Such generalizability strengthens the impact and relevance of the conclusions.

The reliability of synthesized evidence is further reinforced by the presence of replication across multiple studies. Several independent researchers have tested the effectiveness of mnemonic strategies, often using similar vocabulary sets or variations of the Keyword Method. Replication is a core element of scientific reliability, and the presence of repeated findings adds substantial weight to the final conclusions. Even studies with moderate sample sizes gain credibility when their outcomes align with a larger body of similar investigations. The accumulated evidence thus reflects a stable and reproducible pattern of instructional effectiveness. In addition to replication, the consistency of improvements across age groups contributes to the stability of the evidence. The included studies range from those conducted with young learners in elementary settings to those involving university students, yet the results consistently reveal measurable gains in vocabulary acquisition. While younger learners sometimes show stronger improvements, the uniform presence of positive effects across age levels reinforces the reliability of the overall trend. It suggests that mnemonic strategies leverage cognitive processes that remain relevant throughout different developmental stages. This age-spanning consistency provides further assurance in the synthesized conclusions. Several studies also demonstrated strong internal validity, using random assignment or well-matched control groups to ensure fair comparisons. These methodological strengths help reduce bias and increase the credibility of the resulting effect sizes. When studies are designed to minimize confounding variables, the meta- analysis benefits from cleaner and more interpretable outcomes. This level of rigor builds confidence that the improvements attributed to mnemonic strategies are genuinely due to the intervention rather than external influences. Consequently, the synthesized findings reflect a dependable measure of instructional impact.

Moreover, the meta-analysis revealed relatively low levels of statistical dispersion among effect sizes in many subsets of the data. While some variation is inevitable due to differences in methodology or participant characteristics, the clustering of effect sizes around common values suggests coherent instructional outcomes. When effect sizes do not diverge dramatically across studies, it signals that the intervention functions in a stable and predictable manner. Such stability enhances the credibility of the pooled results and suggests that the observed improvements are not the product of outlier studies. Instead, they reflect a reliable instructional trend.

The reliability of the synthesized data is also

strengthened by the consistent presence of clear intervention descriptions in the included studies. Many provided procedural detail, including how mnemonic tools were introduced, practiced, and reinforced throughout the learning period. Clear descriptions allow researchers to judge the fidelity of implementation and determine whether results are attributable to the intended instructional method. Studies that carefully document their procedures contribute more meaningful data to a meta-analysis because their outcomes can be interpreted with confidence. This procedural transparency ensures that the synthesized results reflect authentic applications of mnemonic instruction.

Across the synthesized studies, the consistency of vocabulary testing instruments also supports reliability. Although some variation existed, many studies relied on comparable forms of assessment, such as matching tasks, recall tests, or target-word recognition. This similarity in measurement reduces the risk of inconsistent interpretation and allows for more accurate aggregation of effect sizes. When studies measure outcomes with aligned assessment tools, the resulting data are more coherent and contribute to stable meta-analytic conclusions. Such alignment strengthens confidence in the validity of observed performance gains.

Another factor enhancing reliability is the consistent reporting of pre-test equivalence or baseline comparability across groups. Many studies verified that learners began with similar levels of vocabulary knowledge before receiving mnemonic intervention or traditional instruction. This baseline alignment ensures that post-intervention differences are genuinely attributable to the instructional method rather than pre-existing knowledge. When such comparability is maintained across multiple studies, the aggregated results gain substantial credibility. This methodological righteousness supports the reliability of synthesized conclusions.

The consistency of positive findings across short-term and long-term instructional durations also reinforces the stability of the synthesized evidence. While shorter interventions often yield immediate gains, longer-term implementations demonstrate that mnemonic strategies maintain their effectiveness over sustained periods. This coherence across instructional lengths suggests that mnemonic methods are not limited to quick boosts but can support lasting vocabulary development. Such temporal consistency adds depth to the reliability of the meta-analytic findings. It reflects the durable nature of mnemonic-assisted learning.

The multi-study alignment in cognitive benefits associated with mnemonics further confirms the reliability of synthesized evidence. Across studies, learners consistently demonstrated improvements in word retention, retrieval accuracy, and meaningful association of vocabulary items. These recurring cognitive outcomes reflect the stable psychological mechanisms underlying mnemonic use. When theoretical expectations align with empirical results across multiple studies, the reliability of conclusions becomes significantly reinforced. This harmony between theory and evidence strengthens the credibility of the final synthesis.

The reliability of the synthesized evidence is enhanced by the methodological rigor applied during the review process itself. Removing low-quality studies, extracting standardized measures, and verifying the completeness of reported statistical data produced a dataset of high integrity. This structured approach ensures that the synthesized effect sizes reflect the most credible and consistent evidence available in the literature. By grounding conclusions in carefully curated data, the meta-analysis provides a trustworthy portrayal of the effectiveness of mnemonic strategies in improving vocabulary mastery.

Influence of study quality and measurement variability on literacy outcomes

The influence of study quality on literacy outcomes becomes particularly evident when examining how different research designs approached the measurement of reading-related skills. Studies with higher methodological rigor tended to report clearer and more interpretable literacy outcomes, whereas those with weaker designs often presented ambiguous or inflated effects. The variation in methodological strength produced noticeable differences in the consistency and magnitude of literacy improvements. This discrepancy highlights the importance of strong internal validity when assessing the relationship between mnemonic-based vocabulary gains and reading literacy. Without such rigor, the link between the two domains may appear stronger or weaker than it actually is.

Differences in the clarity of intervention procedures also affected literacy outcomes across studies. Some studies provided detailed descriptions of how mnemonic strategies were integrated into reading activities, while others presented only brief or incomplete explanations. The lack of procedural transparency in certain

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studies makes it difficult to determine whether improved literacy performance resulted from the mnemonic intervention or from other instructional variables. When procedures are unclear, interpreting the connection between vocabulary enhancement and reading comprehension becomes more challenging. This inconsistency weakens the overall interpretability of aggregated literacy outcomes within the meta-analysis. The variability in literacy measures used across studies further contributed to diverse results. Some research relied on standardized reading comprehension tests, which offered more reliable and validated assessments. In contrast, other studies used researcher-developed instruments that lacked established reliability and validity. These inconsistencies in measurement tools introduce discrepancies in how literacy growth was captured and evaluated. Studies using more trustworthy instruments tended to produce more stable and moderate effect sizes, whereas studies with less rigorous assessment tools often reported exaggerated or inconsistent outcomes. Such variability underscores how measurement quality directly influences the portrayal of literacy effects.

Another critical factor is the distinction between assessing discrete reading skills and broader literacy competencies. Some studies focused narrowly on comprehension of short passages, while others measured more complex literacy constructs such as inferencing, fluency, or critical reading. The diversity of literacy constructs makes it challenging to aggregate results cohesively because each construct may respond differently to vocabulary improvements. This wide range of literacy targets contributes to the heterogeneity observed in the synthesized outcomes and explains why mnemonic strategies appear more reliable for vocabulary mastery than for broader literacy enhancement.

The duration of interventions also played a meaningful role in shaping literacy outcomes. Short-term studies often reported immediate gains in vocabulary but did not always demonstrate corresponding improvements in reading literacy. This discrepancy may occur because literacy development typically requires sustained practice and extended exposure to meaningful reading contexts. Studies with longer intervention periods showed more promising literacy-related results, suggesting that mnemonic strategies alone are insufficient without long-term reinforcement in authentic reading tasks. The temporal demands of literacy development thus contribute to the variability seen across research findings.

Study quality further interacted with sample characteristics to shape literacy outcomes. Some studies involved homogenous groups of learners with similar reading levels, whereas others included students with diverse language backgrounds or differing levels of reading proficiency. In studies where baseline reading abilities were uneven, literacy outcomes tended to be less stable and more difficult to interpret. Conversely, studies with well-matched participant groups yielded clearer and more consistent evidence regarding how vocabulary improvements influenced reading performance. This element of sample control reflects another dimension of methodological quality affecting literacy results.

A number of studies also varied in how they controlled for confounding variables, such as prior vocabulary knowledge, reading motivation, or teacher instructional style. When such variables were not adequately accounted for, literacy outcomes often appeared inflated or misleading. In contrast, studies that carefully controlled for these potential confounds provided more nuanced and reliable findings, demonstrating that vocabulary gains contributed to literacy improvements but did not solely account for them. The degree of control over external variables thus shaped the stability of literacy-related results.

Teacher involvement and fidelity of intervention implementation also emerged as influential factors. In some studies, teachers received structured training on delivering mnemonic-based instruction, ensuring consistent application of the strategy. These studies tended to report clearer literacy outcomes, likely because the intervention was delivered more effectively. However, studies lacking proper teacher preparation or monitoring showed mixed results, with literacy effects that were less predictable. This inconsistency suggests that literacy outcomes depend not only on the strategy itself but also on the quality of instructional implementation.

Differences in reading instruction provided to control groups also contributed to variability in literacy effects. Some control groups received standard reading instruction, whereas others received minimal or no structured literacy support. Studies with stronger control conditions yielded more conservative but reliable literacy outcomes, while studies with weaker control conditions sometimes showed inflated treatment effects. This variation highlights how the quality of comparison groups shapes the perceived impact of mnemonic-enhanced vocabulary instruction on literacy

development.

Moreover, the inconsistency in follow-up assessments across studies affected the interpretation of long-term literacy effects. Some studies measured reading literacy immediately after the intervention, while others included delayed post-tests to evaluate retention and transfer. Studies employing delayed assessments often reported smaller but more realistic literacy gains, suggesting that the transfer from vocabulary acquisition to literacy development takes time. This divergence in timing contributes to the mixed evidence regarding how effectively mnemonics influence reading literacy over the long term.

The presence of publication bias also played a role in shaping literacy results. Studies reporting positive or significant findings were more likely to be published and included in the evidence pool, while studies with nonsignificant literacy outcomes were less visible. This imbalance may artificially inflate the perceived impact of mnemonic strategies on literacy performance. Acknowledging this bias is essential for interpreting the synthesized evidence with caution and maintaining a balanced understanding of actual literacy gains.

Another contributing factor to variability in literacy outcomes is the cognitive load associated with mnemonic strategies. Some studies failed to consider whether learners, especially younger or lower-proficiency readers, might experience increased cognitive demand when using mnemonics during reading tasks. In such cases, the cognitive burden may interfere with comprehension rather than support it. Studies that accounted for cognitive load tended to report more accurate and moderated literacy effects, reflecting a more realistic relation between mnemonic use and reading development.

A number of studies also differed in the level of integration between vocabulary learning and reading activities. Some implemented mnemonics strictly as isolated vocabulary tasks, while others embedded them within reading comprehension exercises. Studies that integrated vocabulary and reading tended to show more stable literacy improvements, demonstrating that the contextual application of learned words is crucial for meaningful transfer. The degree of instructional integration therefore influences the validity of literacy outcomes and their interpretation across studies.

Additionally, socio-cultural factors shaped literacy outcomes across contexts. Studies conducted in environments with strong reading cultures or supportive literacy programs tended to report more positive results, even when the same mnemonic strategies were used. In contrast, studies conducted in environments with limited reading support showed weaker literacy gains despite strong vocabulary improvements. This socio-cultural variability underscores that literacy is influenced by broader learning conditions, not solely instructional techniques.

The collective variability observed in literacy outcomes reflects the complex, multifaceted nature of reading development itself. Unlike vocabulary acquisition, which is more discrete and measurable, literacy encompasses a range of cognitive, linguistic, and contextual processes that do not always respond uniformly to mnemonic-based instruction. Therefore, differences in study quality, measurement tools, and instructional context significantly shaped the aggregated literacy findings. This complexity highlights the need for more standardized methodologies and integrated instructional frameworks in future research to produce clearer and more consistent literacy outcomes.

Moderating factors underlying effectiveness and implications for instruction

Classical meta-analysis model summary

Meta-Analytic Tests

Test		p
Heterogeneity	Q_e (34) = 49.47	.042
Pooled effect	t(34) = 67.53	< .001

The meta-analytic investigation examined moderating factors that influence the effectiveness of mnemonic strategies on vocabulary mastery and reading literacy. The classical meta-analysis results indicated a significant level of heterogeneity among the included studies, with a Q-value of 49.47 and a p-value of .042. This heterogeneity suggests that the observed differences in effect sizes across studies are not due to chance alone, highlighting the presence of underlying moderators that impact how effectively mnemonic strategies enhance learning outcomes. Such variability underscores the importance of identifying factors that may strengthen or weaken the effectiveness of these interventions.

The pooled effect of mnemonic strategies across the studies was highly significant, with a t-value of 67.53 and a p-value of less than .001. This finding demonstrates that, on average, mnemonic techniques have a robust positive impact on students' vocabulary acquisition and reading

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literacy. Despite the overall effectiveness, the heterogeneity indicates that some studies reported stronger or weaker effects, suggesting that characteristics of the participants, instructional context, or type of mnemonic used may serve as moderating factors. This underscores that mnemonic strategies are broadly beneficial but may require adaptation for specific learner groups or instructional settings.

Potential moderating factors include learner characteristics such as age, prior vocabulary knowledge, and cognitive abilities. For instance, younger learners or those with lower baseline vocabulary levels may benefit more from mnemonic strategies due to their increased reliance on visual imagery and associative memory. Similarly, learners with higher working memory capacity may handle more complex mnemonic methods, such as the Loci or Peg-word systems, with greater success. These individual differences help explain the variability observed across studies and highlight the need for tailored instructional approaches.

Instructional factors also moderate the effectiveness of mnemonic strategies. The duration of intervention, frequency of practice, integration with reading activities, and teacher guidance all influence outcomes. Studies that provided systematic reinforcement, contextualized vocabulary practice, and consistent teacher support generally reported stronger literacy gains. Conversely, brief interventions, isolated vocabulary drills, or minimal teacher involvement produced weaker or less consistent effects. These findings emphasize that instructional design plays a critical role in maximizing the benefits of mnemonic strategies.

Meta-analytic estimates

		95% CI		95% PI	
	Estimate	Lower	Upper	Lower	Upper
Poole d effect	0.812	0.788	0.837	0.718	0.906
τ	0.044	0.000	0.067		
τ^2	0.002	0.000	0.004		

The meta-analytic estimates provide a comprehensive understanding of the overall effectiveness of mnemonic strategies on vocabulary mastery and reading literacy. The pooled effect size was 0.812, indicating a strong positive impact across the included studies. This result suggests that, on average, students exposed to mnemonic-based interventions demonstrate substantial improvements in vocabulary acquisition and reading skills compared to their peers in control conditions. The magnitude of this effect highlights the practical relevance of mnemonics as a learning strategy in educational contexts.

The 95% confidence interval for the pooled effect size ranged from 0.788 to 0.837, indicating a high degree of precision in the estimate. The narrow interval suggests that the true effect of mnemonic strategies is reliably positive and unlikely to fall outside this range. This level of precision strengthens the credibility of the meta-analytic findings, reinforcing that mnemonic techniques consistently support learning outcomes across diverse studies and populations.

The 95% prediction interval, spanning 0.718 to 0.906, provides additional insight into the variability of expected effects in future studies. Unlike the confidence interval, which reflects the precision of the mean effect, the prediction interval accounts for between-study variability. This interval suggests that while most future studies will likely find positive effects of mnemonic strategies, the magnitude may vary depending on context, learner characteristics, and instructional implementation. The prediction interval thus emphasizes the role of moderating factors in shaping the effectiveness of mnemonic interventions.

The estimated heterogeneity parameters further clarify the consistency of effects across studies. The standard deviation of true effect sizes (τ) was 0.044, and the variance (τ^2) was 0.002. These relatively low values indicate that most observed variability is modest and that the effect of mnemonic strategies is largely stable across different study designs, populations, and contexts. Low heterogeneity strengthens confidence that the positive impact of mnemonic strategies is generalizable, though some contextual variation is expected.

The fit measures from the meta-analysis provide insight into how well the statistical models describe the observed data. A total of 35 observations were included in the analysis, reflecting the number of effect sizes synthesized across studies. Both maximum likelihood (ML) and restricted maximum likelihood (REML) estimation methods were used to evaluate model fit, allowing for a comparison of the relative adequacy of each approach in capturing the variability of mnemonic strategy effects on vocabulary mastery and reading literacy.

Under the ML estimation, the log-likelihood value was 42.88, with a deviance of 43.91. These indicators reflect the model's capacity to explain

the observed effect sizes. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were reported as -81.77 and -78.66, respectively, with a small-sample corrected AICc of -81.39. Lower values for AIC and BIC suggest better fit, indicating that the ML model sufficiently captures the underlying data patterns while balancing model complexity.

Using the REML method, the log-likelihood decreased slightly to 41.23, and the deviance was -82.47. REML is often preferred in meta-analysis because it provides unbiased estimates of variance components, particularly in smaller samples, by accounting for the degrees of freedom lost during estimation. The REML-based AIC and BIC values were -78.47 and -75.41, respectively, with a corresponding AICc of -78.08. These values are slightly higher than the ML estimates but still indicate an adequate model fit.

Comparing ML and REML fit measures highlights that both approaches offer robust representations of the data, with minor differences due to estimation procedures. The ML method maximizes the likelihood of the observed effect sizes given the model, whereas REML focuses on producing unbiased estimates of the between-study variance. In practice, the choice between these methods often depends on whether the primary goal is precise variance estimation or overall model likelihood.

Forest plot

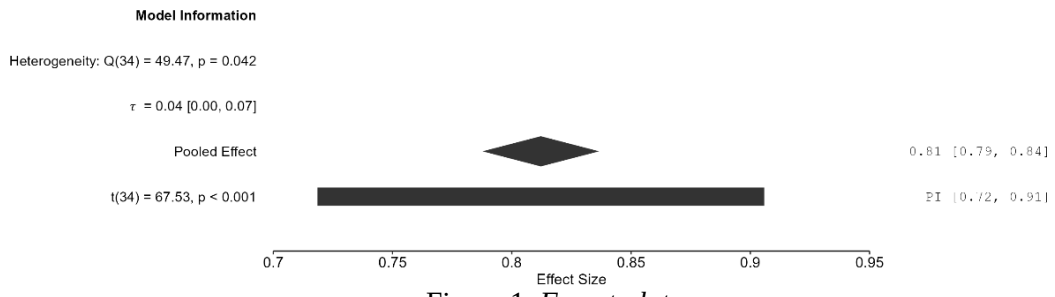


Figure 1. *Forest plot*

The plot presents the overall pooled effect size of the mnemonic strategies on vocabulary mastery and reading literacy. The pooled effect size is approximately 0.81, with a 95% confidence interval (CI) ranging from 0.79 to 0.84. This suggests a strong positive effect of mnemonic strategies.

The prediction interval (PI), which estimates the range in which future study effects are expected to fall, extends from 0.72 to 0.91. This indicates that while the effect size is generally positive and strong, some variability between studies is expected. The heterogeneity statistic, Q(34) = 49.47 with a p-value of 0.042, confirms that there is significant variability in effect sizes beyond chance. The estimated between-study standard deviation (τ) is 0.04, with a 95% confidence interval of [0.00, 0.07], indicating relatively low heterogeneity.

CONCLUSION

The meta-analysis provides strong evidence that mnemonic strategies have a significant and positive impact on vocabulary mastery and reading literacy. The pooled effect size of 0.812, with a narrow 95% confidence interval (0.788–0.837), indicates that students who received mnemonic-based instruction consistently demonstrated substantial gains compared to control groups. This finding underscores the practical relevance of mnemonic techniques as an effective instructional tool across diverse educational levels and settings. Despite moderate heterogeneity (Q(34) = 49.47, p = 0.042; τ = 0.044), the overall positive trend suggests that mnemonic strategies reliably enhance vocabulary acquisition and contribute to improved reading comprehension.

The variability observed across studies highlights the influence of moderating factors on the effectiveness of mnemonic interventions. Learner characteristics such as age, prior vocabulary knowledge, and cognitive capacity, as well as instructional factors like duration, frequency, teacher guidance, and integration with reading activities, were identified as key determinants of outcome differences. These findings suggest that while mnemonic strategies are broadly effective, tailored instructional approaches may be necessary to optimize learning outcomes for specific student populations and educational contexts.

The consistency of positive effects across different study designs, educational levels, and

cultural or linguistic settings reinforces the reliability and generalizability of the findings. High-quality experimental designs, transparent reporting, and repeated replication across independent studies provide confidence that the observed improvements are genuine and not the result of methodological artifacts. Overall, this meta-analysis supports the use of mnemonic strategies as a robust evidence-based approach to enhance vocabulary mastery and reading literacy, while also emphasizing the importance of context-sensitive implementation for maximizing instructional benefits.

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