Cendekiawan: Jurnal Pendidikan dan Studi Keislaman
Vol 4 No 3 2025, p. 814-820
Avaliable online at: https://zia-research.com/index.php/cendekiawan
p-ISSN: 2963-8682 || e-ISSN: 2962-7915

CENDEKIAWAN:
JURNAL PENDIDIKAN DAN STUDI KEISLAMAN
Volume 4 Nomor 3 Tahun 2025 Page 814-820
https://zia-research.com/index.php/cendekiawan

Integration of Language and Mathematical Intelligence in Improving Elementary School Students' Literacy

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Abstract

Elementary school students' literacy levels are often separated between language skills and mathematical reasoning, resulting in partial and less impactful improvement efforts. This research aims to systematically examine evidence on the integration of language and mathematical intelligence to improve elementary school students' literacy. The method used was a systematic literature review (SLR) based on PRISMA guidelines, searching Scopus, WoS, ERIC, and Google Scholar databases with combinatorial keywords such as "language intelligence," "mathematical reasoning," "integrated literacy," and "elementary students" for the period 2014–2025. Inclusion criteria included empirical studies in elementary education, language-mathematics integration interventions or models, and reporting of literacy learning outcomes; exclusion criteria included non-empirical studies and educational levels beyond elementary school. Selection was carried out in stages (identification, duplication screening, abstract title screening, full review), followed by quality assessment using the Mixed Methods Appraisal Tool (MMAT) checklist. Data were extracted and synthesized through a narrative thematic mapping of intervention design, task modalities, outcome metrics, and implementation conditions. Results demonstrate consistent improvements in inferential understanding, translation across textual representations of graphs, tables, and evidence-based argumentation, particularly in the design of authentic multimodal tasks that orchestrate reading, reasoning, writing, and arithmetic. Consequently, this integration strengthens reading and numeracy literacy while fostering early data literacy; practical implications emphasize an integrated thematic curriculum, teacher capacity building for multimodal tasks, and integrated formative assessment that captures both the process and the product of learning.

Keywords: *Elementary School, Integrated Literacy, Language Intelligence, Mathematical Reasoning.*

PRELIMINARY

Calls to strengthen elementary students' literacy often treat language and mathematics as separate competencies, despite converging evidence that linguistic processes and quantitative reasoning develop in tandem and mutually reinforce comprehension, problem solving, and academic attainment across schooling (Spencer, et.al., 2023; Raehang, et.al., 2025). Conceptually, an integrated literacy paradigm links meaning-making in text to meaning-making in symbols and representations, positioning language as a vehicle for mathematical reasoning and mathematics as a context for precise communication, argumentation, and sense-making (Espinas & Fuchs, 2023). Within this framing, core literacy practices—interpreting texts, constructing explanations, justifying claims—map onto core mathematical practices—modeling, representing, and proving—suggesting that integration is not additive but constitutive of elementary learning (Vallejo-Vargas & Reid, 2024).

In practice, however, classroom instruction frequently compartmentalizes reading and numeracy blocks, reducing opportunities for students to translate across modalities such as text, tables, and graphs, or to develop argumentation that blends evidence from language and mathematics (Forde, et.al., 2023). Large-scale evidence shows that foundational language and numeracy skills jointly predict later mathematics performance, yet typical curricula and pacing guides still isolate these domains, constraining transfer and limiting cumulative growth (Chang, 2023). International assessments and national reports similarly point to uneven development of data and information literacies in primary grades, underscoring unmet needs for integrated, multimodal tasks that tie reading, interpreting, and quantifying to real-world contexts.

Empirically, the nexus between language and mathematics is well established. Longitudinal and cross-sectional studies indicate that numerical cognition mediates relations between early competencies and later reading and math outcomes, implying bidirectional influences and shared cognitive substrates. Instructional research further shows that explicit attention to language—vocabulary, discourse structures, and syntax of word problems—improves students' problem solving and conceptual understanding, especially for multilingual learners. These findings motivate designs in which reading, writing, and mathematical reasoning are co-taught rather than sequenced, enabling students to leverage linguistic resources to structure quantitative arguments (Chval, et.al., 2015).

At the same time, observational and materials analyses reveal persistent gaps in integrated opportunities. Despite reforms that broaden the repertoire of word problem types, students' performance patterns remain tied to exposure and linguistic framing, indicating that surface diversification is insufficient without deeper work on discourse and representation (Schoen, et.al., 2023). Reviews of integrated STEM units likewise show that mathematics is often underrepresented or operationalized at low cognitive demand, limiting the kinds of literacy-rich reasoning—justification, generalization, modeling—that drive robust learning (Larkin & Lowrie, 2023).

Systematic evidence on integrated literacy initiatives suggests promise when designs explicitly orchestrate multimodal tasks and align assessment with targeted practices. A recent systematic review of integrated language, science, and technology in elementary schools reports positive effects on diverse outcomes, with larger impacts for tightly integrated, shorter-duration interventions coupled with teacher professional development (Rhodes, et.al., 2024). Complementary syntheses on integrated STEM document benefits of inquiry- and project-based approaches but also emphasize the need to make the "M" mathematically substantive and to scaffold discourse, representation, and argument as literate practices within mathematical activity (Le, et.al., 2023; Larkin & Lowrie, 2023).

In today's data-rich environment, early data literacy offers a compelling arena for integration. Comparative curriculum analyses and primary studies highlight the feasibility and value of engaging elementary students in reading data displays, interpreting distributional stories, and writing evidence-based conclusions—activities that inherently blend language comprehension with quantitative reasoning (Ow-Yeong, et.al., 2023; Hasanah, et.al., 2024). Policy reports and international studies on computer and information literacy further underscore the urgency of cultivating these capacities early, noting declines or uneven performance and calling for instruction that weaves data interpretation, critical reading, and argumentation across subjects.

Taken together, the literature exposes a clear gap: while theory posits a tight coupling between linguistic and mathematical proficiencies, and select interventions demonstrate gains from integration, mainstream elementary practice and assessment rarely sustain high-cognitive-demand tasks that require coordinated reading, representing, modeling, and justifying over time (Schoen, et.al., 2023). Moreover, many integrated STEM implementations under-specify disciplinary discourse moves and cross-representation translations, leading to claims of integration without consistent opportunities for students to construct and critique quantitative arguments in language-rich contexts (Larkin & Lowrie, 2023; Le, et.al., 2023).

This systematic literature review responds to that gap by synthesizing evidence from the past decade on integrated language–mathematics approaches for elementary learners, with a focus on multimodal tasks, discourse scaffolds, and assessment practices that capture both process and product. Anchored in PRISMA procedures, the review interrogates not only effects but also design features that enable students to traverse text–table–graph representations and to articulate warrants linking data to

claims (Rhodes, et.al., 2024). In doing so, it integrates insights from cognitive-developmental research on reading–math linkages with design studies of classroom discourse and argumentation (Spencer, et.al., 2023; Vallejo-Vargas & Reid, 2024).

The novelty of this work lies in foregrounding "integrated literacy" as a unifying construct spanning reading comprehension, mathematical reasoning, and early data literacy, and in specifying design principles for authentic, mathematics-forward integration at the primary level. By centering cross-representation translation, explicit language scaffolds, and formative assessment aligned to argument quality, the review advances a concrete pathway for moving beyond parallel blocks toward a coherent curriculum that builds mutually reinforcing competencies essential for contemporary learning and citizenship.

METHOD

This study employed a systematic literature review focused on the integration of language and mathematics to enhance elementary students' literacy. Guided by established review procedures for education research, we defined the problem, constructed and piloted search strings, and registered inclusion and exclusion criteria prior to screening (Le, et.al., 2023; Larkin & Lowrie, 2023). Searches were conducted in Scopus, Web of Science, ERIC, and Google Scholar for peer-reviewed articles published between 2015 and 2025 using combinatorial keywords such as "language literacy," "mathematical reasoning," "integrated literacy," "elementary/primary," and "data literacy." We included empirical or review studies at the primary level that reported outcomes related to reading comprehension, mathematical reasoning, data or statistical literacy, multimodal representation, or argumentation; we excluded non-empirical pieces, secondary or tertiary contexts, and studies without clear integration of language and mathematics. The review setting encompassed international research across formal classroom and curriculum contexts.

Data sources comprised full-text articles meeting criteria and their reference trails. Data collection proceeded in four stages: identification, duplicate removal, title–abstract screening, and full-text eligibility review, followed by forward–backward citation chasing for saturation. We extracted study characteristics (country, grade, design), integration features (task types, discourse scaffolds, representations), outcome measures, and implementation conditions using a structured template adapted for K–12 integration research. Analysis combined narrative synthesis with comparative cross-case mapping of design features and outcomes, and thematic coding of integration mechanisms (e.g., text–table–graph translation, argumentation, modeling). To evaluate the credibility of findings, we applied standardized quality appraisal criteria aligned to study designs and triangulated evidence across methodologies and contexts; we also compared patterns against recent domain reviews to check robustness and potential publication bias.

FINDINGS AND DISCUSSION

Language-focused scaffolds embedded in mathematics instruction reliably improve word-problem performance

Across included studies, interventions that explicitly target language comprehension within mathematics tasks show consistent gains in students' ability to parse schemas, construct situation models, and map propositions to operations in word problems. Programs blending direct instruction in text structures, domain-specific vocabulary, and relational language with schema-based problem solving yielded superior outcomes to conventional problem practice alone. Effects are strongest when instruction makes the linguistic features of problem types explicit, rehearses academic sentence frames for justifying steps, and sequences worked examples with prompted self-explanations. This pattern suggests that comprehension processes are not ancillary but constitutive to elementary problem solving and should be designed as such rather than remediated after the fact.

These effects generalize across learner subgroups, including multilingual students, when scaffolds emphasize both meaning and form. Studies report improved solution accuracy and more coherent written justifications, indicating an integrated impact on quantitative reasoning and communicative clarity. The fidelity elements most associated with gains include explicit teaching of comparison and change schemas, morphological unpacking of math vocabulary, and structured discourse routines for explaining, arguing, and concluding.

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Vocabulary and discourse design are key mechanisms linking reading and math gains

Synthesis across articles indicates that growth in mathematics word-problem performance is mediated by targeted development of academic vocabulary and discourse practices. Interventions that systematize how learners encounter, rehearse, and deploy high-utility terms and structures—such as quantifiers, relational prepositions, and causal connectors—produce measurable improvements in both text comprehension and transfer to novel problem types. Designs that layer oral rehearsal, writing frames, and dialogic routines cultivate precision and coherence in students' mathematical communication, which in turn predicts problem-solving success.

Moreover, vocabulary work that is embedded in authentic mathematical activity outperforms decontextualized pre-teaching lists. When terms are introduced through tasks that require representing quantities, comparing magnitudes, and justifying operations, learners appropriate language as a tool for reasoning rather than as inert definitions. This is reflected in students' written explanations, where increased lexical diversity co-occurs with more accurate statement of conditions, assumptions, and warrants.

Multimodal and integrated task designs amplify effects, especially for multilingual learners

Tasks that require coordinated translation across text, tables, and diagrams strengthen both comprehension and quantitative reasoning. Studies report that when instruction foregrounds cross-representation moves—identify quantities in text, align them to tabular structure, and annotate operations in diagrams—students generate more accurate models and fewer misinterpretations of relational language. The benefits are pronounced in designs that scaffold collaborative talk and writing about representations, prompting students to externalize and refine their mathematical narratives.

Integrated designs also appear to narrow performance gaps for students developing the language of instruction. By orchestrating multimodal input and output, teachers reduce cognitive load from purely linguistic processing and provide alternate routes to meaning. Over time, these experiences bootstrap academic language growth: students adopt genre-appropriate moves such as stating claims, citing data from representations, and articulating reasoning chains that connect givens, operations, and conclusions.

Discussion

The three findings jointly underscore a central implication for elementary literacy–mathematics integration: language is not merely a barrier to be removed but a resource to be engineered into problem solving. When instruction surfaces the linguistic architecture of problem types and equips students to navigate it—through explicit schema teaching and relational language focus—problem-solving accuracy rises because students can construct and manipulate situation models with greater fidelity.

Furthermore, a description of the analysis of the findings is presented in the table below:

Table 1. Analysis of Research Findings

Aspect	Key Findings	Implications	Source
Language Scaffolding in Mathematics	Language support (text comprehension, vocabulary, sentence structure) in story problems improves the accuracy of problem solving and written justification.	Explicit teaching of mathematical vocabulary and sentence structures improves the clarity of students' arguments.	Fuchs et al. (2019); Espinas & Fuchs (2022).
The Role of Academic Vocabulary & Discourse	Mastery of academic vocabulary and discourse practice is the link between reading growth and successful math problem solving.	Vocabulary diarahkan pada penggunaan dalam konteks nyata, bukan daftar kata terpisah.	Black & Wright (2023); Chval et al. (2015).
Multimodal Tasks & Representational Integration	Assignments that combine text, tables, diagrams, and graphs strengthen understanding as well as quantitative reasoning.	Students more accurately model problems if guided to move between representations.	Larkin & Lowrie (2023); Rhodes et al. (2024).

Support for Multilingual Learners	Multimodal integrative design narrows the achievement gap for multilingual students by reducing the cognitive load of language.	Sentence frames, partner talk, and visual scaffolding strengthen participation and the quality of solutions.	Baird et al. (2020); Spencer et al. (2022).
The Role of Teachers and Sustainability	Teacher competencies are important for implementing literacy–mathematics integration: analyzing problem texts, designing representation transitions, and building discourse routines.	Teacher training needs to focus on planning language-mathematics integration.	Kornhaber et al. (2004); Hasanah et al. (2024).

These findings confirm that the integration of linguistic and mathematical intelligence has a significant impact on improving elementary school students' literacy. Language is not merely a barrier, but rather a key resource for developing mathematical situation modeling, representation, and argumentation. By incorporating academic vocabulary, argumentative sentence structures, and discourse exercises, students are able to explain mathematical solutions more precisely and convincingly (Fuchs et al., 2019; Espinas & Fuchs, 2022).

Furthermore, multimodal learning designs that orchestrate text, tables, and graphs familiarize students with shifting between representations, strengthening critical thinking skills and data literacy from an early age. For multilingual students, this integration serves a dual purpose: strengthening mathematical understanding while developing academic language skills (Baird et al., 2020; Rhodes et al., 2024). Consequently, teachers and curricula need to position linguistic and mathematical integration as a core practice, not an add-on, within elementary school literacy.

Vocabulary and discourse emerge as the levers that translate reading gains into mathematical performance. Rather than treating "key word" spotting as a shortcut, effective designs cultivate deep lexical and syntactic awareness tied to mathematical functions, such as specifying conditions, comparing quantities, and expressing proportional or additive relations. The Reading Psychology synthesis highlights that strategic choices in vocabulary instruction—design, spacing, and alignment to tasks—shape downstream comprehension and application, reinforcing the need to embed language learning within mathematical activity.

For multilingual learners, content-language integration within mathematics (for example, the MELD approach) reframes language development as a consequence of engaging in rigorous math practices rather than a prerequisite. Scaffolds like sentence frames for justification, modeled think-alouds that bind language to representation, and structured partner talk enable students to participate in high-cognitive-demand tasks while building the discourse moves of the discipline. Reported improvements in both participation and solution quality suggest that equitable access and achievement are aligned when language supports are integral to task design.

The convergent evidence also argues for a multimodal pedagogy. Requiring students to move between text, tables, and diagrams provides redundant cues and distributed representations that stabilize meaning. These translations are inherently linguistic acts—labeling units, stating relationships, and narrating processes—and so become fertile sites for language growth. As students practice articulating why a table supports a particular operation or how a diagram encodes a comparison, they refine the precision and cohesion of mathematical explanations.

From a design perspective, the strongest interventions align goals, tasks, and assessments. If outcomes include the quality of written mathematical argument, then lessons must provide explicit models, guided practice, and feedback on claims, evidence, and warrants. Assessments should capture both solution correctness and discourse quality, ensuring that instructional signals and evaluative criteria reinforce one another. The vocabulary review's emphasis on design coherence dovetails with this alignment imperative in integrated classrooms.

Sustainability hinges on teacher learning. The studies point to fidelity elements—explicit schema instruction, relational language focus, and structured discourse routines—that can be translated into professional learning modules and planning tools. Because these practices are content-embedded rather

than add-ons, they are more likely to persist. Coaching that helps teachers analyze problem texts for linguistic demands and pre-plan representation shifts can further institutionalize integration.

At the systems level, adopting integrated materials has implications for pacing and collaboration. ELA and mathematics blocks should be planned for complementary goals, with shared rubrics for explanatory writing and common expectations for evidence use. School-wide emphasis on argumentation and data use provides coherence across grades and subjects, compounding gains as students encounter similar discourse moves in new contexts.

Finally, the review suggests avenues for future work: specifying dosage and sequencing of language targets within math units, differentiating supports for various problem schemas, and developing sensitive measures of discourse growth tied to mathematical understanding. Strengthening the evidence base on long-term transfer—how early integration affects later algebraic reasoning and data literacy—would further justify systemic adoption of these integrated approaches.

CONCLUSION

The review finds that embedding language-focused scaffolds within mathematics instruction reliably improves elementary students' word-problem performance by strengthening situation-model construction, schema use, and clarity of written justifications. Academic vocabulary and discourse are the key mechanisms linking reading growth to problem solving, with the strongest effects when terms and structures are taught in context and tied to authentic reasoning and representations. Multimodal, integrated task designs that require translation across text, tables, and diagrams further amplify gains and are especially beneficial for multilingual learners, narrowing performance gaps while improving both accuracy and explanation quality.

Implications are to treat integration as core pedagogy: engineer language comprehension, vocabulary, and discourse into math tasks, talk, and writing, and align assessment to value both correctness and the quality of explanations and cross-representation moves. Recommended actions include embedding explicit schema and relational-language targets in word-problem units, designing tasks that enforce movement among representations with sentence frames and talk moves for claims–evidence–warrants, and teaching vocabulary in use via worked examples and brief writing-to-learn. Build teacher capacity with planning tools that surface linguistic demands and pre-plan representation shifts, and prioritize integrated, equity-oriented supports for multilingual learners so language development is a consequence of rigorous mathematical activity.

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