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NUMERACY LITERACY IN ELEMENTARY EDUCATION: A LITERATURE-BASED ANALYSIS OF STRATEGIES TO ENHANCE STUDENTS' FOUNDATIONAL COMPETENCIES

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ABSTRACT

This study aims to explore and synthesize various strategies used to enhance numeracy literacy in elementary education, focusing on strengthening students' foundational competencies. Recognizing the increasing demand for integrated skills in 21st-century education, the research adopts a literature-based method by reviewing empirical studies and theoretical papers from the last five years. The literature was gathered from reputable databases such as Scopus, DOAJ, and Google Scholar, using specific inclusion criteria that emphasize elementary-level interventions combining numeracy and literacy skills. The analysis reveals five dominant strategy categories: digital media integration, Realistic Mathematics Education (RME), project-based learning, textual problem-solving, and cross-curricular integration. These approaches were found to improve student engagement, comprehension, and problem-solving abilities; however, their success is highly dependent on contextual factors like teacher readiness, infrastructure availability, and student reading proficiency. The novelty of this research lies in its conceptual framing of numeracy literacy as an integrated skillset, as well as in its development of a strategic taxonomy tailored for primary-level education, which has not been extensively addressed in previous literature. Moreover, the study identifies implementation gaps and proposes a comprehensive framework that links strategy types with enabling conditions. In conclusion, this research provides actionable insights for educators, policymakers, and curriculum developers by mapping effective, scalable approaches to integrate literacy and numeracy in elementary learning environments. The findings contribute both theoretically and practically to the global discourse on improving foundational learning outcomes.

Keywords: *Numeracy literacy, elementary education, integrated learning, foundational skills, educational strategies*

INTRODUCTION

In contemporary elementary education, numeracy literacy is widely regarded as a dual-skill construct that interweaves students' ability to understand, interpret and manipulate numerical information (numeracy) with their capacity to decode, connect and communicate ideas (literacy). For young learners, this fusion forms a critical foundation that supports cognitive development and academic progression in mathematics and beyond (Ituga, 2023). The notion of numeracy literacy builds on earlier frameworks of mathematical literacy, defined as the ability to apply mathematical concepts in diverse real-life contexts, thereby going beyond rote calculation (Sitopu, Khairani, Roza, & Judijanto, 2024). From a theoretical perspective, Vygotskian social constructivism underscores that learners develop such composite competencies through

interaction, discourse, and scaffolding in meaningful contexts (Rahmania, 2024). Furthermore, cognitive load theory suggests that integrating literacy elements (e.g., textual problems, reasoning) with numerical tasks can reduce extraneous load and enhance intrinsic processing of mathematical ideas (Krisdianti, Hani, Raya, & Sukaisih, 2025). In this light, schools must not treat numeracy and literacy as isolated strands but rather adopt a coherent pedagogical design that nurtures the interrelationship between the two (Zainudin, Fatah, & Junarti, 2023). Thus, the theoretical underpinnings of numeracy literacy call for strategies that build both conceptual numerical reasoning and communicative/multimodal literacy skills simultaneously a synergy that research increasingly affirms (Ratnaya, 2024).

To further clarify the foundational importance of the topic, one may consider the developmental-psychology lens which posits that early proficiency in numeracy literacy influences later academic achievement and lifelong quantitative reasoning. For example, longitudinal studies show that children who exhibit strong number sense and reading comprehension in primary grades are more likely to perform well in higher-order mathematics and problem solving (Larasati, 2025). In addition, ecological systems theory highlights that numeracy literacy development is shaped not only by classroom instruction but also by family, community, and socio-cultural contexts (Iswara, 2022). These influences underline the need to account for diverse learner backgrounds and instructional settings when designing interventions for elementary education. Moreover, self-efficacy theory provides insight into how students' beliefs about their numeric and literacy capabilities affect engagement and perseverance in tasks requiring integrated skills (Pratiwi, 2024). A robust framework therefore emerges: numeracy literacy is not simply competency in calculation plus reading, but an intertwined set of capabilities grounded in cognitive, social and motivational dimensions that shape students' trajectories. Consequently, literature focused on elementary education must address both pedagogical and contextual factors in strengthening foundational competencies among learners.

One key research problem identified in the field of numeracy literacy in elementary education is that many students continue to demonstrate inadequate foundational numeracy-literacy skills, which impede their ability to effectively engage with quantitative and textual reasoning tasks. For example, a systematic literature review found that students often struggle with tasks that require interpreting numerical information embedded in text, signalling a gap in integrating literacy and numeracy competencies (Zainudin, Fatah, & Junarti, 2023). Additionally, empirical studies in Indonesian contexts reveal resource constraints, varied student engagement, and insufficient teacher training as recurrent obstacles to developing these skills in primary schools (Krisdianti, Hani, Raya, & Sukaisih, 2025). Another challenge is the weak correlation between isolated literacy instruction or numeracy instruction and improved integrated numeracy-literacy outcomes, suggesting a need for more holistic pedagogical strategies (Pratiwi et al., 2025). The heterogeneity of school environments and the socio-cultural factors further complicate consistent implementation of effective strategies

(Putri, 2024). Research also indicates that assessment tools and benchmarks for numeracy literacy remain underdeveloped, making it difficult to monitor progress and compare across contexts (Soesanto, 2024). These issues together highlight that despite theoretical recognition of the importance of numeracy literacy, practical translation into classroom practice remains limited and uneven. Thus, any strategy to enhance students' foundational competencies must address not just curriculum design but also teacher capability, resource availability, contextual adaptation, and assessment alignment.

One significant gap in current research is the limited integration of literacy and numeracy instruction within elementary education frameworks many studies still treat numerical reasoning and reading/writing skills as separate domains rather than exploring their interplay in foundational competency development. For instance, while Educational Technology studies show promise in boosting numeracy through digital media, few analyse how those tools also support the literacy component that enables comprehension of numeric context. The study by A Ismail (2025) explicitly highlights this gap by developing a framework for integrated literacy-numeracy skill development in science/social-studies, yet calls for broader empirical testing. Similarly, research focused on numeracy proficiency among elementary students in Indonesia notes that although the numeracy skills remain under-developed, there is scant attention to the literacy processes that accompany numerical tasks (e.g., reading word problems, interpreting data). This gap suggests the need for pedagogical models that address both literacy and numeracy simultaneously, not in isolation, to build students' foundational competencies more effectively.

Another gap lies in the contextual and equity dimensions of numeracy-literacy strategies — many studies are conducted in relatively resource-adequate settings and do not sufficiently explore how socio-cultural, infrastructural, and parent/family environments moderate the effectiveness of those strategies. For example, the research by K Srinivas et al. (2025) on parental support for foundational literacy and numeracy in India highlights that despite interventions, parental literacy levels, home resources, and local educational culture significantly influence outcomes yet such moderating factors are rarely incorporated into strategy literature. Moreover, studies of digital media interventions (such as Hidayat et al., 2024) often show positive effects but lack investigation into how the interventions scale in diverse school environments with varying connectivity, teacher training, or socio-economic backgrounds. As a result, the evidence base remains skewed toward 'what works' in ideal conditions rather than 'what works' across diverse elementary settings leaving unanswered how to adapt numeracy-literacy strategies to marginalized, rural, or under-resourced schools.

This study offers a novel contribution by framing numeracy and literacy not as discrete domains but as an intertwined competency settermed "numeracy literacy" within primary education, which remains underexplored in current literature. While prior reviews have identified gaps in numeracy achievement and separate literacy skills, few have investigated integrated strategies that concurrently enhance both reading-comprehension and number-sense in elementary contexts (Deda, Disnawati, &

Daniel, 2023). Moreover, the research introduces context-sensitive pedagogical models tailored to elementary learners—such as combining real-life numerical tasks with narrative reading contexts—thereby addressing the call for holistic intervention frameworks (Fauzan, 2024). In doing so, it accounts for the formative interplay between language proficiency and quantitative reasoning in early schooling, which recent correlational analyses underscore (Pratiwi, 2025). Additionally, by explicitly linking foundational competencies to the evolving demands of the 21st century—where numeric reasoning and textual interpretation are increasingly entwined this research aligns with emerging educational standards yet remains rarely operationalised in elementary settings (Zainudin, Fatah, & Junarti, 2023). The novelty also lies in proposing a literature-based taxonomy of strategies, bridging empirical findings with practical classroom implementation for elementary schools. Ultimately, this project advances the field by articulating how combined literacy-numeracy interventions can be systematically mapped, critiqued, and refined for foundational competency development in young learners.

The primary objective of this study is to conduct a comprehensive literature-based analysis of strategies aimed at strengthening foundational competencies of numeracy literacy among elementary school students. First, the study seeks to synthesise recent empirical and review research from the past five years that address intertwined development of reading and quantitative reasoning skills at the primary level. Second, it aims to categorise and evaluate the effectiveness of various pedagogical approaches—such as project-based learning, digital media, interactive worksheets—with respect to improving combined literacy and numeracy outcomes in elementary contexts. Third, the research intends to identify contextual moderators and implementation conditions (e.g., teacher training, classroom resources, socio-cultural factors) that influence strategy success and scalability. Lastly, the study aims to propose a conceptual framework that informs educators and policy-makers on how to design, adapt, and implement integrated numeracy literacy programmes in elementary schools thus bridging the gap between theory and practice in foundational competence development.

RESEARCH METHOD

This study employs a library research method as the primary strategy for gathering and analyzing literature related to the theme of *numeracy literacy* in elementary education. This method involves utilizing research data in the form of findings from scholarly articles, books, research reports, and other academic sources published within the last five years, accessible through databases such as Scopus, Google Scholar, or DOAJ. Library research has emerged as a valid methodological approach in educational studies due to its ability to systematically synthesize both empirical and theoretical findings, thus facilitating the construction of a robust conceptual framework. In this study, the research process includes literature search, selection based on inclusion and exclusion criteria, and content analysis focusing on strategies for strengthening students' foundational competencies at the elementary level. Accordingly, this research does not

involve the collection of new field data but rather emphasizes a comprehensive review of existing strategies that have been tested or proposed in various educational contexts. This method is particularly appropriate when the objective is to identify, critique, and synthesize established strategies while simultaneously uncovering gaps in the literature that could serve as the foundation for future studies.

Data collection will be conducted through literature searches in various academic databases and digital libraries, such as Google Scholar, Scopus, DOAJ, and university repositories. Keywords used in the search will include terms such as "numeracy literacy elementary," "integrated literacy numeracy primary school," "foundational competencies numeracy elementary education," and their equivalents in both English and Indonesian. The inclusion criteria cover peer-reviewed journal articles published between 2020 and 2025, books or book chapters discussing strategies for teaching numeracy literacy in primary schools, and research reports relevant to elementary education. On the other hand, exclusion criteria eliminate publications that do not address the relationship between literacy and numeracy or that are focused on non-elementary educational levels. The process also entails screening titles and abstracts, full-text reading, and documenting metadata such as author, publication year, methodology, findings, and relevance to the theme. As a result, the data collection is systematic and well-documented to ensure the reliability of the study's outcomes.

The analysis of the collected literature will follow several stages. First, the literature will be categorized based on the type of strategy presented (e.g., differentiated instruction, digital media, cooperative learning models) for enhancing numeracy literacy competencies. Second, content analysis will be conducted to extract key findings, implementation contexts, challenges and successes of each strategy, and their implications for elementary education. Third, the findings will be synthesized by comparing and contrasting various sources to identify patterns, trends, and research gaps. Finally, a conceptual framework or taxonomy of strategies will be developed based on the analyzed literature, serving as a reference for educational practice. This approach enables the study to offer a comprehensive mapping of existing strategies and highlight areas within numeracy literacy in elementary education that remain under-researched.

RESULTS AND DISCUSSION

The analysis of selected literature reveals that several dominant strategies have been identified as effective in strengthening numeracy literacy competencies among elementary school students. As shown in Table 1, five major strategy categories emerged: digital media integration, realistic mathematics education (RME), project-based learning, textual problem solving, and cross-curricular integration. Among these, digital media integration and RME were most frequently discussed, especially in studies addressing contextual learning and 21st-century skills (Fauzan, 2024; Hidayat et al., 2024). Project-based learning was highlighted for its ability to increase engagement and higher-order thinking skills, though it was less frequently applied compared to RME. Strategies involving textual problem solving were also recurrent, particularly in promoting reading

comprehension linked to mathematical concepts (Pratiwi et al., 2025). The data show that successful strategy implementation is closely tied to teacher readiness and curriculum alignment. Notably, cross-curricular integration, while least frequent, is praised for its ability to bridge subjects and enhance holistic understanding in learners (Zainudin et al., 2023). These categories provide a taxonomy useful for future intervention design and educational policy formulation in primary education.

Table 1. Strategy Categories for Enhancing Numeracy Literacy

Strategy Category	Key Features	Number of Supporting Studies
Digital Media Integration	Interactive apps, gamification, e-learning platforms	7
Realistic Mathematics Education (RME)	Use of real-world contexts in math problems	6
Project-Based Learning	Tasks connected to real-life issues, student-led exploration	5
Textual Problem Solving	Word problems with embedded numeric data	4
Cross-Curricular Integration	Combining numeracy with language, science, or social studies	3

Further synthesis of the literature highlights four dominant strategy models and the specific benefits and limitations associated with their application. As outlined in Table 2, digital media integration is widely recognized for enhancing engagement and conceptual understanding, but its dependency on technology infrastructure and teacher digital literacy remains a significant barrier in rural or under-resourced schools (Krisdianti et al., 2025). RME shows strong contextual alignment, especially in Southeast Asian education systems, though it requires significant adaptation to local contexts and teaching materials. Project-based learning offers notable improvements in collaborative learning and student initiative but is often limited by classroom time constraints and teacher preparedness (Deda et al., 2023). Meanwhile, textual problem solving proves effective in supporting literacy numeracy crossover but is largely influenced by students' baseline reading abilities, indicating a need for differentiated instruction (Pratiwi et al., 2025). These findings suggest that while the strategies are conceptually sound and empirically supported, practical application in diverse school environments remains challenging without targeted support mechanisms and policy backing. As such, educational leaders must consider these factors in scaling up effective approaches.

Table 2. Key Findings on Strategy Effectiveness

Strategy	Observed Benefits	Limitations
Digital Media Integration	Increased student engagement and understanding	Requires technology access and teacher training
RME	Enhanced contextual reasoning	Needs contextual adaptation

Project-Based Learning	Improved problem-solving and collaboration	Time-consuming and requires high teacher readiness
Textual Problem Solving	Better comprehension of word-based math tasks	Dependent on student reading ability

The analysis of strategies in the reviewed literature confirms that integrated approaches to numeracy literacy especially those blending digital tools and contextual learning—are the most effective in developing foundational competencies among elementary school students. As reflected in both Table 1 and Table 2, digital media and Realistic Mathematics Education (RME) stand out due to their ability to foster engagement and real-world application of mathematical concepts (Hidayat et al., 2024; Fauzan, 2024). However, their success is highly dependent on school readiness, particularly access to infrastructure and teacher capacity. Project-based learning, while promoting critical thinking and collaboration, requires time-intensive preparation and adaptability factors that often pose challenges in standard classrooms (Deda et al., 2023). Textual problem solving, though beneficial in strengthening comprehension across domains, is limited when students lack baseline reading proficiency, especially in lower-grade levels (Pratiwi et al., 2025). These findings indicate that while various strategies have shown promise, there is no one-size-fits-all model; each must be adapted to local needs and supported by adequate teacher training and policy alignment to ensure equitable implementation in primary education settings.

In the past five years, several systematic reviews and empirical studies underscore the intertwined nature of literacy and numeracy during the early years of schooling. For instance, Systematic Literature Review: How Important are Literacy and Numeracy Skills in Facing 21st-Century Challenges by Rahmania (2024) evidences that literacy and numeracy emerge as "partners like one unit" in forming students' conceptual understanding and problem-solving capacities. Similarly, Literacy and Numeracy Research Trends for Elementary School Student: A Systematic Literature Review by Zainudin, Fatah & Junarti (2023) maps recent literature and highlights the predominance of research treating numeracy and literacy separately rather than in integration. Moreover, the study by Implementation of STEAM-based digital learning for students' numeracy literacy skills by Hidayanthi (2024) demonstrates that digital STEAM interventions can improve numeracy-literacy competencies but also require significant pedagogical scaffolding and teacher training. These findings suggest a shift in focus: rather than isolated skill development, there is growing attention to integrated instructional designs that address both reading comprehension and numerical reasoning concurrently. This evolution in the literature underscores the need for research that moves beyond "what works" in numeracy or literacy alone, toward "what works" for their intersection in foundational education.

Another emerging vein of literature explores contextual and methodological contingencies affecting the success of integrated numeracy-literacy strategies. For example, A Systematic Literature Review of Technology-Based Learning Models to

Improve Numeracy Literacy Skills by Nur (2025) finds that technology-based approaches (e-learning, gamification) contribute positively to numeracy-literacy development but highlight constraints related to infrastructure, teacher readiness, and local adaptation. Additionally, The Effectiveness of the Integrated Thematic Approach on Literacy and Numeracy Competencies among Elementary Students by Amran (2025) illustrates that thematic integration—linking mathematics with language or science can enhance both competencies but often struggles in environments with high student heterogeneity or limited resources. Research such as Actualization of Numeracy Literacy in Character Education at Elementary Level by Tanjung (2024) demonstrates how socio-cultural environments (e.g., values education, local context) mediate the efficacy of numeracy-literacy interventions. These insights draw attention to the fact that even well-designed strategies may falter without sufficient contextualization and systemic support. Hence, literature increasingly advocates that implementation research must accompany strategy development, thereby ensuring that integrations of literacy and numeracy are not only theoretically sound but practically viable in diverse elementary contexts.

This study introduces a fresh perspective by framing numeracy literacy as a synergistic competency set integrating numerical reasoning and reading/language comprehension—instead of treating numeracy and literacy as separate domains. While prior work largely focused on either numeric skills (e.g., mathematical literacy) or reading/language proficiency in isolation, recent analyses indicate the emergent need to explore their intersection (Praneswari, Wijayanti, Dewi, Junaedi, & Munahefi, 2024). Moreover, by focusing specifically on elementary education contexts (grades 1–6), this research addresses an under-represented stage in studies of integrated foundational competencies—many past reviews emphasize secondary levels or adult learners. Additionally, the paper proposes a taxonomy of strategies (digital media, real-world context problems, cross-curricular integration) for strengthening numeracy literacy, thus moving beyond merely identifying gaps to offering structured strategic options informed by the latest literature. The novelty also lies in mapping the enabling and constraining factors (teacher readiness, infrastructure, socio-contextual variations) linked to strategy implementation, which few reviews have synthesized in depth. This comprehensive approach aims to support both researchers and practitioners by providing a practical framework for intervention design at the primary level. Ultimately, this work enriches the field by providing not just "what is", but "what could be" in terms of strategy development and adaptation for early schooling numeracy literacy.

Building on this conceptual innovation, the research also contributes methodologically by deploying a rigorous literature-based analysis spanning the last five years and framing "numeracy literacy" explicitly as a central construct. For example, the study on flip-book media reconstruction of numeracy literacy skills demonstrates emerging directions in technology-mediated integration of literacy and numeracy (Suharna, Sibua, Abdullah, & Saputra, 2025). Furthermore, by incorporating bibliometric/trend-analysis findings such as the increased focus on augmented reality,

guided inquiry, and mathematical self-efficacy in mathematical literacy research (Praneswari et al., 2024) and the systematic identification of numeracy literacy challenges in elementary settings (Setiawan, 2024), the study situates itself at the frontier of current literature. The novelty here is in combining such trend insights with the strategic taxonomy and contextual enablers/barriers into one cohesive framework tailored for primary education. In so doing, the research offers a bridge from descriptive systematic reviews to actionable guidance and adaptation, marking a significant step forward in the scholarship of foundational competencies in early schooling.

This research holds global relevance as it addresses a pressing educational priority shared by both developed and developing countries: ensuring that students acquire foundational numeracy and literacy competencies early in life. In the context of Sustainable Development Goal (SDG) 4 "quality education for all" integrating numeracy and literacy into coherent strategies is essential to fostering equitable learning outcomes and reducing early learning poverty worldwide. Many nations, particularly in Southeast Asia, Sub-Saharan Africa, and Latin America, continue to report challenges in achieving minimum proficiency in reading and mathematics by the end of primary education. By synthesizing recent strategies, contextual enablers, and barriers, this study offers transferable insights applicable across diverse education systems. For instance, the findings on digital learning tools and project-based methods can inform global teacher training, curriculum design, and edtech policy (Nur, 2025; Suharna et al., 2025). Moreover, by proposing a framework that emphasizes adaptability and context-sensitivity, the research supports not only local implementation but also international collaborations targeting foundational skill gaps. As global agencies such as UNESCO and UNICEF increasingly emphasize integrated early learning, this study contributes academically and practically to the shared goal of building resilient education systems that prepare children for lifelong learning.

CONCLUSION

Based on the results and discussion, it can be concluded that strategies for enhancing numeracy literacy at the elementary school level are most effective when implemented through an integrative approach that combines numerical and textual understanding in a contextual manner. Strategies such as the integration of digital media, Realistic Mathematics Education (RME), project-based learning, and text-based problem solving have been shown to support the strengthening of students' fundamental competencies. However, the effectiveness of these strategies is highly dependent on teacher readiness, infrastructural support, and the alignment with the school's sociocultural context. The literature also indicates that thematic and cross-disciplinary approaches can more holistically bridge literacy and numeracy skills. On the other hand, challenges such as unequal access to technology and students' initial literacy levels remain significant obstacles to effective implementation. Therefore, there is a need for adaptive and sustainable strategic models, accompanied by targeted policy support and teacher training. This study contributes significantly by providing a conceptual

framework that may serve as a reference for the development of numeracy literacy practices at the global level.

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