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Global Perspectives on Literacy-Numeracy Disparities: A Systematic Review of Predictive Factors and Interventions to Foster Equitable Quality Education

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Abstract: This study aims to synthesize global empirical findings on literacy numeracy (LN) through a Systematic Literature Review (SLR) approach. The review focuses on three key aspects: predictive factors of numeracy development, social disparities (including gender and socioeconomic status), and the effectiveness of pedagogical interventions. Data were collected from 15 empirical studies published between 2024 and 2025 and analyzed using thematic synthesis. The findings reveal that numeracy development is influenced by strong cognitive foundations, particularly early numeracy and quantitative language, which act as significant predictors of later mathematical achievement. Neurocognitive evidence also highlights the role of specific brain regions, while family support contributes indirectly through learning environments. Furthermore, significant social disparities persist, where gender and socioeconomic status interact in complex ways to shape numeracy outcomes, with women and low-SES groups consistently showing lower performance. In terms of interventions, domain-specific and differentiated pedagogical approaches, including teacher professional development and contextualized learning, demonstrate effectiveness in improving numeracy skills. However, challenges remain in implementation, particularly in curriculum alignment, assessment bias, and contextual barriers. This study contributes to a comprehensive understanding of literacy numeracy as a multidimensional and context-dependent competence, emphasizing the need for integrated, equitable, and evidence-based educational strategies.

Keywords: Gender gap; Literacy numeracy; Pedagogical intervention; Socioeconomic status; Systematic literature review

Introduction

Literacy numeracy (LN) has become a fundamental competence that enables individuals to function effectively in modern society, particularly in supporting decision-making, problem-solving, and participation in economic and social life (OECD, 2019; Peters, 2012). Despite its widely recognized importance, global evidence continues to reveal persistent gaps in numeracy achievement across different age groups and socio-geographical contexts (OECD, 2023). These disparities are particularly evident in developing countries, where international assessments indicate that students' mathematical literacy remains below the global average (OECD, 2019). However, similar patterns of inequality are also found in developed countries, suggesting that numeracy is a global issue rather than merely a local or regional concern (de Bruin et al., 2021).

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Beyond learning outcomes, recent research has increasingly focused on early predictors of numeracy development, including the role of quantitative language in early childhood education. Quantitative language such as the use of number-related vocabulary, comparisons, and measurement terms has been identified as a foundational component of early numeracy development (Purpura et al., 2017; Susperreguy et al., 2020). In this context, quantitative language can be understood as a precursor within the broader construct of numeracy, particularly in shaping applied skills and conceptual understanding. At the same time, numeracy is increasingly conceptualized as a multidimensional construct that encompasses not only cognitive abilities (applied numeracy and objective understanding) but also affective dimensions such as perceived numeracy or self-efficacy (Peters, 2012). This broader perspective highlights the importance of integrating early predictors with numeracy outcomes across the lifespan.

Although numerous studies have examined specific aspects of numeracy such as early childhood predictors, school-based interventions, or socio-economic disparities there remains a lack of integrative synthesis that connects these fragmented findings across developmental stages and socio-geographical contexts (Johanning et al., 2024; Reyna et al., 2009; Yang et al., 2025). Previous review studies tend to focus narrowly on single dimensions (e.g., early numeracy, gender gaps, or instructional strategies), thereby limiting a holistic understanding of how numeracy develops and varies across contexts.

The novelty of this study lies in its comprehensive synthesis of literacy numeracy research by simultaneously bridging three key dimensions: (1) developmental stages (from early childhood to adulthood), (2) socio-geographical contexts (including both developing and developed countries), and (3) the multidimensional nature of numeracy (encompassing both cognitive and affective aspects). By integrating these perspectives, this study moves beyond fragmented analyses and offers a more cohesive framework for understanding literacy numeracy as a dynamic and context-sensitive competence.

This research is important for several reasons. First, a comprehensive synthesis is needed to clarify inconsistencies in terminology and conceptualization, particularly regarding the relationship between early predictors such as quantitative language and broader numeracy outcomes (Purpura et al., 2017). Second, understanding numeracy across diverse contexts can inform more equitable educational policies and targeted interventions, especially in addressing persistent disparities related to socio-economic status, gender, and geographic location (de Bruin et al., 2021; OECD, 2019). Third, by integrating cognitive and affective dimensions, this study contributes to a more holistic perspective aligned with contemporary educational goals, which emphasize not only skill acquisition but also learners' confidence and agency (John, 2023).

Therefore, this systematic literature review aims to synthesize existing research on literacy numeracy in order to develop a comprehensive understanding of its development, determinants, and variations across age groups and socio-geographical contexts.

Method

This study employs a Systematic Literature Review (SLR) approach that is designed to be systematic, transparent, and replicable, following the guidelines of PRISMA. The purpose of this approach is to comprehensively synthesize empirical findings related to literacy numeracy across various research contexts. Data were collected through a systematic search of reputable scientific databases, including Scopus, Web of Science, and Google Scholar, using combinations of keywords such as "numeracy literacy," "mathematical literacy," "early numeracy," "quantitative language," "socioeconomic status," "gender gap," and "pedagogical intervention," connected through Boolean operators (AND, OR). To ensure relevance and recency, the search was limited to articles published between 2024 and 2025.

The article selection process was conducted in stages following the PRISMA flow, including identification, screening, eligibility assessment, and final inclusion of studies in the analysis. Inclusion criteria were established objectively, encompassing primary empirical studies (quantitative, qualitative, and mixed-methods) that address literacy numeracy, predictive factors of numeracy development, social disparities (gender and socioeconomic status), and educational interventions, and that are available in full-text form. Conversely, articles in the form of literature reviews, meta-analyses, conceptual papers, duplicates, or those not relevant to the research focus were excluded from the selection process. This process was subsequently visualized using a PRISMA flow diagram to ensure transparency in the number of articles at each stage.

Data from the selected studies were systematically extracted, including information on authors, publication year, research context, study design and methodology, sample characteristics, variables examined, and key findings. Data analysis was conducted using a thematic synthesis approach based on the framework proposed by Miles et al. (2014), which involves three main stages: data reduction through coding, data display through thematic categorization, and conclusion drawing through synthesis. Given the heterogeneity of the study

designs included, the synthesis was conducted using a narrative synthesis approach, allowing for the integration of findings from diverse research methodologies. To ensure the quality of the results, each study was also evaluated based on the clarity of research objectives, methodological rigor, validity and reliability of data, and the accuracy of result reporting, ensuring that only studies with adequate methodological quality were included in the analysis.

Result and Discussion

A total of 15 relevant articles were extracted and validated. These articles were predominantly published in international journals (13 articles) from leading publishers such as Elsevier, and supported by two national journals focused on the Indonesian educational context. Table 1 summarizes the identity, methods, and key findings of each article that formed the basis of this review.

Table 1. Validation and Synthesis Results of Numeracy Scientific Articles

Title Journal	Author (Year)	Research methods	Key Findings	Category Journal
The role of the intraparietal sulcus in numeracy	Duricy et al. (2025)	Review Systematic	Left IPS related damage significant with disturbance ability Approximation numeric.	International
Gender, socioeconomic status, and numeracy test scores	Paterson et al. (2024)	Longitudinal Study	Poor girl experiences loss double consequence interaction income low and education Mother.	International
Analysis of Numeracy Literacy for Each Student's Learning Style through.	Munahefi et al. (2024)	*Mixed Methods*	Improvement numeracy through Learning Differentiated. Difficulty found in students with style Study Auditory, Visual, and Kinesthetic.	National
Assessing qualities and biase in ethnomathematics-based numeracy worksheets.	Ramadhani et al. (2025)	*Many-Facet Rasch Model*	Worksheet based Ethnomathematics quality but detected the existence of gender bias and background bias behind education.	International
Direct and indirect associations between parents' and children's literacy and numeracy skills.	Zhang et al. (2025)	Longitudinal Study	Parental numeracy no in a way consistent related with numeracy children, but RAN (speed naming) becomes predictor strong.	International
Early numeracy development as a foundation of mathematics achievement	Dierkx et al. (2025)	*Latent Growth Curve Modeling*	Development Initial Numeration (EN) is non-linear and is predictor strong achievement mathematics in elementary school.	International
Fostering toddlers' numeracy and mathematical language skills through	Besser et al. (2025)	Intervention Study (9 weeks)	Intervention specific mathematics for ECEC teachers to show effect strong in increase numeracy and language mathematics toddlers.	International
Gender Gap in Financial Literacy-Numeracy, Financial Concepts	Iwatsubo et al. (2025)	Survey Literacy Finance	gender gap is driven by scores woman who 7.1 points more low on questions numeric compared to man.	International
Literacy and Numeracy Difficulty Factors in the Independent Learning Curriculum	Saputra et al. (2024)	*Mixed Methods*	Analyze factor difficulty literacy and numeracy in context Independent Learning Curriculum in Middle School (130 students).	National
Parental support for foundational literacy and numeracy skills among schoolchildren	Srinivas et al. (2025)	Qualitative Case Study	Parent in a way active support development children's FLN skills they are in India.	International
Perceived, objective, and applied numeracy in Ghana	Lawrence et al. (2025)	Design Study	Adequate numeracy is component important for interpretation monitoring pressure home blood count (HBPM).	International
Predicting adult literacy and numeracy Findings from the British cohort study	Furnham & Cheng (2025)	SEM (Cohort Study)	Childhood intelligence is predictor strongest literacy and numeracy adults, accounted for 53% of the variance.	International

Title Journal	Author (Year)	Research methods	Key Findings	Category Journal
State and wealth inequalities in foundational literacy and numeracy skills in Nigeria	Azubuike et al. (2024)	Multilevel Logistic Regression	Inequality significant in FLN is driven by wealth House households, communities, and states.	International
The gendered value of education in the 'college-for-all' era and the role	Gelbgiser & Gabay- Egozi (2025)	Analysis of data from 26 countries (PIAAC)	Women are more prone to to misalignment skills (numeracy) in the supply era graduate of tall	International
The links between quantitative versus spatial language knowledge	Chan et al. (2025)	Cross-Lagged Panel Models	Knowledge Language relational (quantitativeand spatial) related positive with development skillsnumeracy in kindergarten children.	International

Synthesis thematic of the 15 journals analyzed produce three theme discussion that explains dynamics literacy numeracy (LN) in various context. This theme in a way collective describe LN starting from foundation cognitive until manifestations and challenges social.

Foundation Cognitive and Predictors Development Numeracy

This pillar focus on the roots cognitive and neurological from numeracy as well as track its development since age early.

Non-Linear Development and Language Interrelationships

Longitudinal studies confirm that development numeracy Early Numeracy (EN) is non-linear, indicating period the strongest growth during kindergarten, which then flat in Class 1. Strong EN development proven become predictor significant for performance mathematics at school basis (Dierkx et al., 2025). In general cognitive, language quantitative (eg term comparison magnitude) in kindergarten children becomes predictor strong prospects against LN, compared with Language spatial (Chan et al., 2025). Findings this supported by interventions that found that training development mathematics-specific teacher professional (PD) produce improvement numeracy older toddlers strong and long -lasting (Besser et al., 2025).

Neurological Basis and Support Family

In a way neuropsychologically, LN has a specific causal basis. Review systematic case parietal lesions confirmed that damage to the left Intraparietal Sulcus (IPS) specific related with deficit in ability Approximation (Duricy et al., 2025), strengthens theory that this area important for representation magnitude. In the context of family, study show that active parental support in developing LN tends to use approach-based games and activities (Srinivas et al., 2025), despite from importance environment home, relationship direct between skills calculation parent - child arithmetic found weak and domain- specific, indicating that mechanism transmission intergenerational Possible no directly (Zhang et al., 2025).

The gap Social, Gender, and Inequality

This pillar analyse How factor socio-economic manifest inequality in achievement numeracy.

Gender Gap and Skill Values Cognitive

Gender gap in LN is not only occurs in context academic, but also has an impact significant in the functional domain. In literacy finance, women get score 7.1 points more low on questions numeric compared to man, showing that low literacy finance related close with skills more numerical weak than understanding formal concept (Iwatsubo et al., 2025). Analysis cross country more carry on strengthen findings this: in the era of "college" For all, "the labor market Work value skills cognitive (numeracy) above formal credentials (degrees), which contribute to the gap income Because woman tend own skills numeracy more cognitive low compared to men (Gelbgiser et al., 2025).

Inequality and SES Interactions

Inequality numeracy/literacy the basic (FLN) is multilevel. In the context of developing countries, it is found that that FLN is highly influenced by wealth communities and states, showing that factor contextual in various scale geographical own impact substantial, beyond effect riches House ladder individuals (Azubuike et al., 2024). In addition, the relationship between Socioeconomic Status (SES) and gender shows unique interaction: child Woman get benefit from education mother, meanwhile child man from House ladder income tall precisely get benefit from structure House ladder traditional (mother at home) (Paterson et al., 2024). This show the need interventions that take into account dynamics House complex stairs.

Effectiveness Interventions and Challenges Implementation Curriculum

This pillar evaluated success intervention pedagogical and challenges faced in implementation of the LN program.

Intervention Domain-Specific Pedagogy Approach intervention must nature specific.

Implementation Learning Differentiated assisted ORIENT media based Thinglink on junior high school students is proven effective increase LN (N-gain 0.4031) and is able to accommodate difficulty unique to each style learning (Munahefi et al., 2024). On the other hand methodological, although sheet Work numeracy based ethnomathematics considered quality (Ramadhani et al., 2025), the Many-Facet Rasch Model (MFRM) analysis revealed the existence of gender and background bias behind significant education of the rater, emphasizing the need calibration instruments and training assessor.

Numeracy Applications and Obstacles Contextual

In context health applied, there are discrepancy between perceived numeracy (belief self) and numeracy applied (ability interpret results medical). The study found that ability patient interpreting increased data significant when served with combination numbers and codes color (Lawrence et al., 2025). Finally, the difficulties of LN in Indonesia are related to close with obstacle implementation curriculum, with lack of implementation indicator success, especially in the aspects of Community Base and School Culture (Saputra et al., 2024). This show that intervention must supported by strong policies and implementation-based community.

Conclusion

Based on the synthesis of 15 empirical studies, this research demonstrates that literacy numeracy is a multidimensional competence influenced by the complex interaction of cognitive, social, and pedagogical factors. From a cognitive perspective, numeracy development is strongly determined by early numeracy skills and quantitative language, which serve as powerful predictors of later mathematical achievement. In addition, neurocognitive evidence indicates that numeracy abilities have a specific biological basis, while the family environment contributes indirectly through learning support. From a social perspective, disparities in literacy numeracy remain a significant global issue. Gender and socioeconomic status (SES) exhibit complex and interacting effects, with women and individuals from lower SES backgrounds tending to achieve lower numeracy outcomes. This highlights the importance of interventions that are sensitive to social contexts and structural inequalities. From a pedagogical perspective, various domain-specific instructional interventions, differentiated learning approaches, and teacher professional development have been shown to be effective in improving numeracy literacy. However, implementation in practice still faces several challenges, including assessment bias, limitations in measurement instruments, and barriers in curriculum implementation. Overall, this study emphasizes that improving literacy numeracy requires a holistic, integrated, and evidence-based approach that simultaneously considers cognitive, social, and pedagogical factors. These findings are expected to serve as a foundation for the development of more equitable and effective educational policies and interventions.

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