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Learning quality factors associated with students' literacy and numeracy competencies: a systematic literature review

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ABSTRACT

The low literacy and numeracy competence of Indonesian students is a serious concern, as reflected in the 2022 PISA score, which is still below the international average. Learning quality is a key factor suspected to significantly influence the development of these two basic competencies. This study aims to systematically analyze the influence of learning quality on improving literacy and numeracy competencies based on empirical literature studies. The research uses the Systematic Literature Review (SLR) approach with the PRISMA protocol. Literature searches were conducted on indexed databases (Scopus, ERIC, SINTA, Google Scholar) with keywords related to learning quality, literacy, and numeracy. Of the 896 initial articles, 38 met the inclusion criteria for further analysis. The analysis shows that the quality of learning has a significant influence on literacy and numeracy competence through various dimensions: (1) the quality of teacher-student interaction and relational-intentional pedagogy; (2) teachers' competence in compiling HOTS and AKM-based questions; (3) the implementation of the independent curriculum and contextual approach; (4) the use of innovative technology and learning media; (5) learning environment at home and school; and (6) teacher training and professional development. Optimizing learning quality through a holistic approach that includes improving teachers' pedagogic competence, strengthening the literacy-numeracy-based curriculum, and integrating technology has proven effective in improving students' literacy and numeracy competencies. This study recommends sustainable policies for teacher professional development and improvement of learning infrastructure.

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Introduction

Literacy and numeracy competencies are widely recognized as fundamental skills that support academic achievement, lifelong learning, and successful participation in the twenty-first century (Han, 2017; *PISA 2018 Assessment and Analytical Framework*, 2019). Beyond enabling students to read, write, and calculate, these competencies equip individuals with the capacity to analyze information critically, solve problems, make informed decisions, and adapt to increasingly complex social and technological environments.

Consequently, improving literacy and numeracy has become a major educational priority across many countries seeking to enhance the quality of human resources and strengthen future competitiveness.

Despite continuous educational reforms, literacy and numeracy achievement in Indonesia remains a major concern. Studies have consistently reported that students' literacy skills have not yet reached the expected level, and the learning loss experienced during the COVID-19 pandemic has further widened this gap (Nasrullah et al., 2024). This condition is also reflected in the Programme for International Student Assessment (PISA) 2022, in which Indonesia obtained a reading literacy score of 359, mathematics 366, and science 383, substantially below the OECD averages of 476, 472, and 485, respectively (OECD, 2023). Although Indonesia's ranking improved by several positions compared with PISA 2018, the decline in absolute scores indicates that learning recovery remains a significant challenge (Kemendikbudristek, 2023). Similar findings have also been reported at the regional level, where junior high school students in Karawang demonstrated relatively low numeracy literacy, with an average score of only 36.64, indicating considerable disparities across achievement groups (Hikmah et al., 2024). Collectively, these findings suggest that strengthening literacy and numeracy remains an urgent priority within the Indonesian education system.

Previous studies have identified numerous factors associated with students' literacy and numeracy development. One important factor is the home learning environment, where family educational background, the frequency of literacy and numeracy activities, the availability of learning materials, children's interests, and the quality of parent-child interactions collectively contribute to the development of these competencies (Kumar & Behera, 2022). Likewise, parental involvement has been shown to play an important role in supporting children's learning. However, parents generally report engaging more frequently in literacy-related activities than numeracy-related activities, indicating that literacy tends to receive greater attention within the home environment than numeracy. Understanding the characteristics of home literacy and numeracy environments is therefore essential for identifying strategies that encourage parents to provide more balanced learning support for their children (Napoli et al., 2021).

In addition to family-related factors, technology-supported learning has increasingly been recognized as an important contributor to literacy and numeracy development. Previous studies indicate that digital skills, educational videos, and digital games can effectively facilitate students' literacy and numeracy learning experiences (Deda et al., 2023). Nevertheless, the effectiveness of these approaches remains dependent on students' existing foundational competencies, as many learners continue to experience difficulties in basic reading and mathematics. Similar concerns are evident in Indonesian schools, where numeracy literacy has not yet been fully integrated into the implementation of the School Literacy Movement (Gerakan Literasi Sekolah), while foundational literacy activities are often implemented inconsistently across educational settings (Rakhmawati & Mustadi, 2022). These findings suggest that improvements in learning resources alone are insufficient without broader efforts to strengthen the quality of learning experienced by students.

This relationship can be explained through Bronfenbrenner's Bioecological Theory, which posits that children's learning and development are shaped by continuous interactions between individuals and multiple environmental systems, including the family, school, and broader educational contexts (Cassells & Evans, 2020). This perspective suggests that literacy and numeracy competencies are not developed solely through learners' individual abilities but also through the quality of learning experiences provided within these interconnected environments. Consistent with this view, previous studies have demonstrated that supportive home learning environments, meaningful teacher–student interactions, and high-quality instructional practices collectively contribute to students' literacy and numeracy development (Darling-Hammond et al., 2020). Furthermore, effective learning quality serves as an important mechanism through which educational environments facilitate students' cognitive development and academic achievement, thereby strengthening literacy and numeracy competencies across diverse educational contexts (Erdem & Kaya, 2024; Rawlings et al., 2024).

Literacy represents more than the mechanical ability to read and write. It encompasses the ability to understand, analyze, evaluate, and critically engage with information in diverse contexts (Hazin et al., 2025). As a cognitive process, literacy supports critical thinking, analytical reasoning, the comprehension of complex ideas, and evidence-based decision making (Abella et al., 2024). Within contemporary educational settings, literacy has also expanded into digital contexts. Teachers' digital literacy, for example, has been shown to enhance pedagogical competence substantially, indicating that the effective integration of digital literacy can contribute to the delivery of higher-quality learning in twenty-first-century education (Lianandaya et al., 2025).

Similarly, numeracy extends beyond computational skills and involves the ability to understand, interpret, and apply quantitative information in everyday situations (Siregar et al., 2025). Numeracy includes understanding numerical concepts, arithmetic operations, patterns, spatial reasoning, measurement, statistical information, and mathematical problem solving that can be transferred into authentic real-life contexts (Siregar et al., 2025; Hazin et al., 2025). Furthermore, numeracy literacy encompasses the ability to utilize mathematical symbols and concepts, interpret quantitative information presented in tables, graphs, and charts, and apply analytical results to solve practical problems encountered in daily life (Darwanto et al., 2021). Accordingly, literacy and numeracy should be viewed as complementary competencies that jointly support students' academic success and lifelong learning.

Building upon these perspectives, learning quality has increasingly been recognized as one of the most influential factors in fostering students' literacy and numeracy competencies. Rather than referring solely to academic achievement, learning quality encompasses the effectiveness of teaching and learning processes, including teacher–student interactions, instructional strategies, curriculum implementation, assessment practices, learning resources, classroom environments, and the meaningful integration of technology. Previous studies consistently indicate that inadequate learning quality contributes substantially to low literacy and numeracy achievement (Darling-Hammond et al., 2017; Egert et al., 2018). Persistent challenges remain in teachers' ability to design higher-order thinking skills (HOTS)-based assessments, while classroom instruction in many schools continues to rely predominantly on teacher-centered approaches, memorization, and limited use of educational technology (Fiangga et al., 2019; Rohim et al., 2021). Conversely, effective teacher–student interaction, appropriate pedagogical practices, relevant curricula, and supportive learning environments have been consistently associated with improved literacy and numeracy outcomes (Siraj et al., 2023; Wolf & McCoy, 2019). Furthermore, strengthening numeracy literacy increasingly requires data-informed educational practices supported by digital leadership and accessible technology to respond to contemporary educational challenges (Putri & Basir, 2026).

Although previous studies have provided important evidence regarding literacy, numeracy, and learning quality, the existing body of knowledge remains fragmented in several respects. First, most studies examine literacy and numeracy as separate educational outcomes, resulting in limited understanding of how learning quality simultaneously contributes to the development of both competencies. Second, previous research has predominantly focused on isolated dimensions of learning quality, such as teacher competence, instructional media, digital learning, or parental support, without integrating these dimensions into a comprehensive understanding of learning quality. Third, empirical evidence has been generated across different educational levels, schools, and regional contexts, yet systematic synthesis that identifies consistent patterns across these diverse findings remains limited. Consequently, educational stakeholders continue to lack comprehensive evidence regarding which dimensions of learning quality most consistently support literacy and numeracy development across different learning contexts.

To address these limitations, a comprehensive synthesis of existing empirical evidence is required to consolidate current knowledge, identify recurring dimensions of learning quality, and clarify their relationships with literacy and numeracy competencies. Rather than generating new primary data, synthesizing findings from previous empirical studies enables a broader understanding of the evidence accumulated across different educational contexts and provides a stronger basis for evidence-informed educational decision-making.

Unlike previous studies that have primarily examined individual determinants of literacy or numeracy, this study contributes by synthesizing empirical evidence to identify the dimensions of learning quality that most consistently influence both competencies simultaneously. In addition, this study integrates findings across diverse educational contexts to provide a more comprehensive understanding of the relationships between learning quality and literacy–numeracy competencies while generating evidence-informed recommendations that may support educational policy and learning improvement, particularly within the Indonesian context.

Accordingly, this study aims to (1) identify the dimensions of learning quality that influence literacy and numeracy competencies; (2) analyze the relative contribution of each learning quality dimension to literacy and numeracy outcomes; (3) synthesize empirical evidence regarding the relationships between learning quality and literacy–numeracy competencies; and (4) formulate evidence-informed recommendations for improving learning quality to strengthen literacy and numeracy competencies.

Method

Data Analysis

Data were extracted using a standardized extraction form containing information on the authors, publication year, study objectives, research design, participants, dimensions of learning quality, literacy and numeracy variables, and principal findings. The extracted findings were analyzed using inductive thematic analysis. Initially, relevant findings related to learning quality and literacy–numeracy competencies were coded. Similar codes were subsequently grouped into broader categories through an iterative comparison process. Finally, categories that consistently appeared across the included studies were synthesized into overarching themes representing the dimensions of learning quality. The analysis continued until no new themes emerged from the included studies, resulting in six recurring dimensions of learning quality.

Research Design

This study employed a Systematic Literature Review (SLR) following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). The SLR approach was selected because it enables a systematic, transparent, and reproducible synthesis of empirical evidence concerning the relationship between learning quality and literacy and numeracy competencies. The review process consisted of four stages: identification, screening, eligibility assessment, and inclusion, as illustrated in the PRISMA flow diagram (Figure 1).

A systematic search was conducted in Scopus, ERIC, SINTA (Science and Technology Index), and Google Scholar. Search terms were organized into three concept groups: learning quality ("quality of learning", "teaching quality", "instructional quality", "professional development", and "teacher competence"), literacy ("literacy", "reading literacy", and "language literacy"), and numeracy ("numeracy", "mathematical literacy", and "quantitative literacy"). Boolean operators (AND/OR) were used to combine search terms. The search was limited to journal articles published between 2019 and 2026 in English or Indonesian.

The next stage is screening, which involves selecting references that align with the writing's objective. There are four literature criteria to be studied, namely empirical research articles (quantitative, qualitative, or mixed methods) that discuss the relationship between learning quality and literacy/numeracy, the population of students at the PAUD to university levels, and the full text is available. Meanwhile, the manuscripts excluded from the study are non-empirical articles (opinions, reviews without data analysis), do not explicitly discuss the quality of learning or literacy/numeracy, do not have complete texts available, and are publications before 2019. Following the identification stage, duplicate records were removed automatically and manually before title and abstract screening. Articles were screened according to predefined inclusion and exclusion criteria. Only empirical studies investigating the relationship between learning quality and literacy and/or numeracy among student populations from early childhood education to higher education were retained for further assessment.

The next stage was the eligibility assessment. At this stage, the abstracts and full texts of the screened articles were carefully evaluated to determine their relevance to the research objectives and compliance with the predefined inclusion criteria. Subsequently, the methodological quality of the eligible studies was assessed using standardized critical appraisal tools according to the study design. The Critical Appraisal Skills Programme (CASP) checklist was applied to qualitative studies, while the Joanna Briggs Institute (JBI) Critical Appraisal Checklist was used for quantitative studies. These instruments were employed to evaluate methodological rigor, including the appropriateness of the research design, sampling procedures, data collection methods, data analysis, and the credibility of the findings. Only studies that met the methodological quality standards were included in the final synthesis. Following this process, 38 articles fulfilled all eligibility criteria and were included in the systematic literature review.

Table 1 <List of Article Titles>

Title
Benchmarking Literacy and Numeracy: The Contributing Elements.
Pengaruh Contextual Teaching and Learning terhadap Pemahaman Teks Bacaan Siswa Kelas V SD
Implementing creative learning with technology to improve literacy and numeracy in primary schools.
Analisis Kebutuhan Pengembangan Media Board Game Untuk Meningkatkan Kemampuan Literasi Siswa Kelas III SD
Effective Teacher Professional Development.
Penguatan Literasi, Numerasi, dan Adaptasi Teknologi Pada Pembelajaran di Sekolah

Title
Impact of in-service professional development programs for early childhood teachers on quality ratings and child outcomes: A meta-analysis.
Pengaruh Kompetensi Pedagogik dan Kompetensi Profesional Pendidik Mata Pelajaran Sejarah Kebudayaan Islam Terhadap Literasi Digital Peserta Didik.
Penulisan soal literasi numerasi bagi guru SD di Kabupaten Ponorogo
Materi pendukung literasi numerasi.
The Value of Smarter Teachers International Evidence on Teacher Cognitive Skills and Student Performance
Empowering Elementary Students: A Model for Enhancing Literacy and Numeracy Skills to Overcome Learning Loss.
Analisis Kemampuan Literasi Numerasi Siswa SMP dalam Menyelesaikan Soal Cerita pada Persamaan Linier Satu Variabel
Efektivitas e-Modul Pembelajaran Matematika Untuk Meningkatkan Kemampuan Literasi Numerasi Siswa
Numeracy literacy skills of elementary school students through ethnomathematics-based problem solving
Rapor Pendidikan Indonesia Tahun 2023
Pengaruh Literasi Digital Terhadap Kompetensi Pedagogik di Era Pendidikan Abad Ke-21 pada Guru SD Supriyadi Semarang.
Establishing Literacy Foundations : Policies and Interventions for Indonesia's Future Excellence.
Literature Review on Longitudinal Study of Improving Numerical Literacy at Elementary Education.
Relationship Between Numeracy and Vocabulary Skills in Indonesian Preschool Children and the Impacts of Learning Environments.
PISA 2022 results (Volume I): The state of learning and equity in education.
Implementation of numeracy literacy training for teachers and its achievement in Central Maluku Regency
Integrasi Data-Driven Decision Making (DDDM) dalam Penguatan Literasi Numerasi Pelaku UMKM
Teacher characteristics that play a role in the language, literacy and math development of dual language learners
Konsep Asesmen Kompetensi Minimum untuk Meningkatkan Kemampuan Literasi Numerasi Siswa Sekolah Dasar
Independent curriculum learning management to improve students' literacy and numerical competence in schools
Kemampuan Literasi Numerasi Matematika Melalui Penerapan Model Pembelajaran Problem Based Learning (PBL)
Improving quality of teaching and child development: A randomised controlled trial of the leadership for learning intervention in preschools
Analysis of Numeracy Literacy of Junior High School Students in AKM Questions: Learning Strategies Based on Higher Order Thinking Skills at SMP Negeri 5 Tapung Hilir
Pengaruh Microlearning Berbasis Website Terhadap Kemampuan Literasi Numerasi Siswa Kelas VI Pada Materi Pecahan.
The effectiveness of mathematics learning videos to support students' numerical and digital literacy skills.
Experimental impacts of the Quality Preschool for Ghana interventions on teacher professional well-being, classroom quality, and children's school readiness.
The PRISMA 2020 statement: An updated guideline for reporting systematic reviews.
Influence of home environment on children's foundational literacy and numeracy skills: A systematic synthesis with India in focus.
The circumstances of literacy numeracy skill: Between notion and fact from elementary school students.
Characteristics Related to Parent-Child Literacy and Numeracy Practices in Preschool.
Efektivitas e-Modul Pembelajaran Matematika Untuk Meningkatkan Kemampuan Literasi Numerasi Siswa
The Influence of School Principal Leadership on The Improvement of Literacy and Numeracy Achievements Based on Education Reports at Junior High School

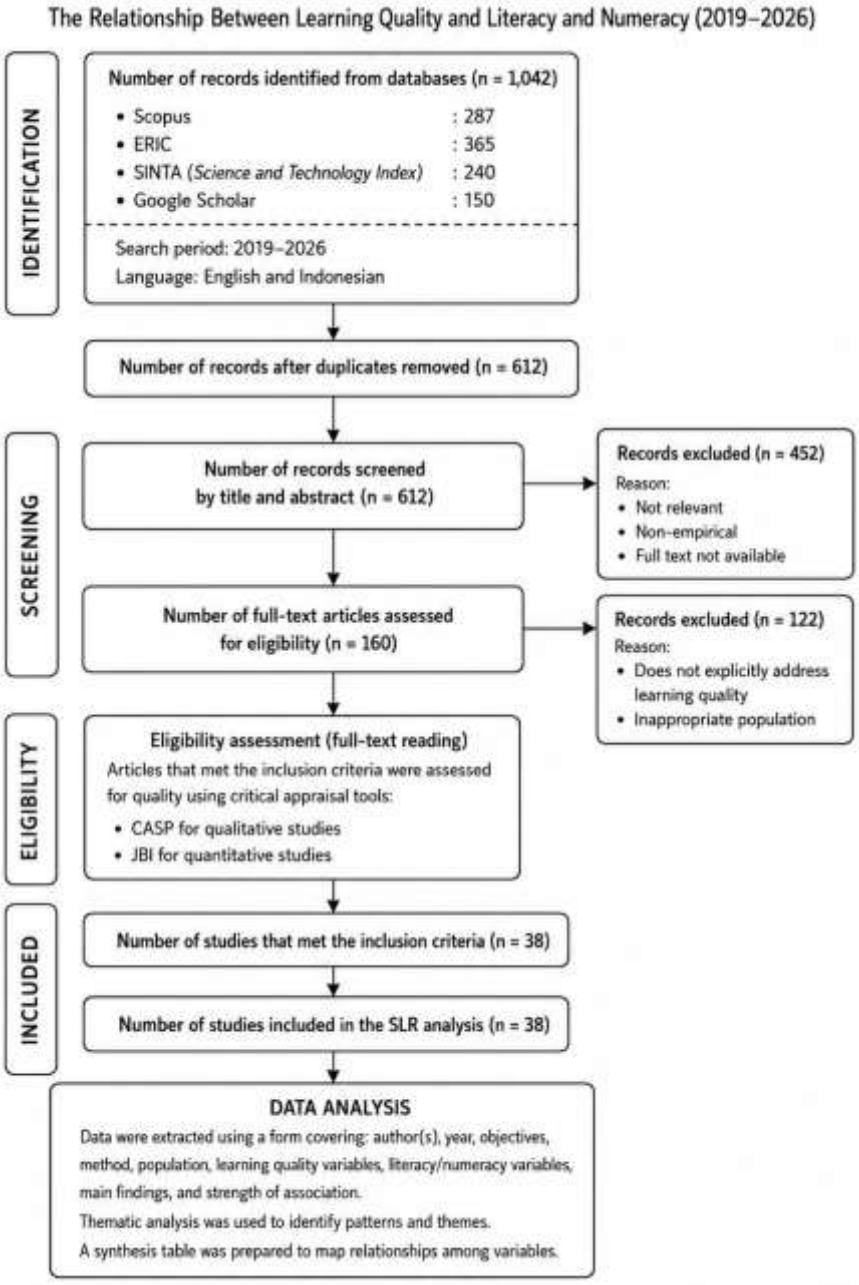

Figure 1 <Research Prisma Diagram>

Results and Discussions

Of the 38 articles analyzed, most originated from Indonesia (27 articles), while the remaining studies were conducted in other developing regions, including Africa, Latin America, and Asia. The educational settings represented in the reviewed studies included early childhood education/kindergarten (9 articles), elementary school (14 articles), junior high school (6 articles), senior high school (3 articles), and higher education (5 articles). In terms of research methodology, quantitative studies were the most dominant (21 articles), followed by qualitative (9 articles) and mixed-methods studies (7 articles).

Following the descriptive analysis of the included studies, a thematic synthesis was conducted to identify recurring patterns related to learning quality and students' literacy and numeracy competencies. The extracted findings were compared across studies and grouped according to conceptual similarities, resulting in six recurring dimensions of learning quality. These dimensions consistently appeared across different

educational contexts and research designs, indicating that they represent the most frequently reported factors influencing students' literacy and numeracy competencies.

The six dimensions identified through the thematic synthesis are (1) teacher competence and professional development, (2) quality of teacher–student interaction and pedagogy, (3) curriculum and learning approaches, (4) use of technology and learning media, (5) learning environment at home and school, and (6) school management and teacher collaboration. The synthesis of these dimensions is presented in Table 2, while the following sections discuss each dimension based on evidence extracted from the reviewed studies.

Table 2. The Synthesis of Learning Quality Dimensions

Dimension of Learning Quality	Key Indikator	Influence on Literacy	Influence on Numeracy	Supporting Studies
Teacher Competence & Professional Development	Continuous training, preparation of HOTS/AKM questions, pedagogic	High (β=0.10-0.14 for literacy)	Height (β=0.08-0.16 for numeracy)	Siraj et al., 2023; Ramírez et al., 2018; Hanushek et al., 2019
Quality of Teacher-Student Interaction	Relational & intentional pedagogy	High (significant improvement in the Verbal Comprehension DAS)	High (significant increase in PENS)	Siraj et al., 2023; Wolf et al., 2019; Hartika et al., 2022
Curriculum & Learning Approach	Independent Curriculum, CTL, PjBL, ethnomathematics	Medium-High (31.2% increase)	Medium-High (17.5% increase)	Rosnelli & Ristiana, 2023; Siregar et al., 2025 ; Iswara et al., 2022
Utilization of Technology & Media	Gamification, AR, AI, e-modules, learning videos	High (80% engagement increase, 25-40% understanding)	High (25-40% increase in comprehension)	Anggun et al., 2025 ; Huda et al., 2024
Learning Environment at Home & School	Home literacy/numeracy environment, parental support	Medium-High (significant correlation)	Medium-High (significant correlation)	Novita et al., 2024 ; Moruk & Sulisworo, 2024
School Management & Teacher Collaboration	Leadership, school culture, learning community	From 51.11% in 2022 to 86.67% in 2025	From 31.11% in 2022 to 74.42% in 2025	Asyha et al., 2025

Teacher competence and professional development emerged as one of the most influential dimensions of learning quality affecting students' literacy and numeracy competencies. Across the reviewed studies, this dimension encompasses pedagogical competence, the ability to develop Higher-Order Thinking Skills (HOTS)-based assessment instruments, continuous professional development, teachers' cognitive competence, and the implementation of effective instructional approaches.

Palinussa et al. (2023) found that numeracy literacy training for teachers in Central Maluku achieved an average activity score of 90.92% (very good category), enabling participants to develop numeracy literacy assessment items aligned with the latest curriculum standards. Similarly, Siraj et al. (2023), through a randomized controlled trial involving 83 Australian early childhood education services, demonstrated that the Leadership for Learning professional development program significantly improved teaching quality. ECERS-E scores increased from 3.17 to 4.03 ($p<0.05$), while SSTEW scores increased from 4.00 to 4.90 ($p<0.05$), which subsequently contributed to improvements in children's language development, early numeracy, and social-emotional outcomes.

Similar findings were reported in international comparative studies. Ramírez et al. (2018) showed that increased teacher training positively influenced children's achievement in both English and Spanish while simultaneously strengthening teachers' cultural competence, thereby supporting literacy development. Likewise, Hanushek et al. (2019), using cross-country PIAAC and PISA datasets, reported that a one-

standard-deviation increase in teachers' literacy and numeracy competencies was associated with approximately a 10–15% standard-deviation increase in student achievement. In addition to cognitive competence, teachers' pedagogical expertise in selecting appropriate instructional approaches also plays an important role. Aina et al. (2026) demonstrated that the Contextual Teaching and Learning (CTL) approach significantly improved elementary students' reading comprehension, suggesting that contextual learning can serve as an effective instructional strategy for improving literacy outcomes.

Collectively, these findings indicate that teacher competence extends beyond subject-matter mastery to include pedagogical expertise, assessment literacy, instructional innovation, and continuous professional development. Evidence derived from randomized controlled trials, cross-country analyses, and school-based intervention studies consistently demonstrates that strengthening teachers' competencies contributes directly to improvements in literacy and numeracy through multiple pathways, including improved instructional quality, effective assessment practices, culturally responsive teaching, and the implementation of student-centered learning approaches.

The reviewed literature further indicates that sustainable improvements in learning quality require long-term investment in teachers' professional and cognitive capital. Hanushek et al. (2019) and Aina et al. (2026) consistently demonstrated that improvements in teacher competence are associated with higher student achievement. Likewise, Faisal et al. (2024) reported significant positive relationships between pedagogical competence and digital literacy (39.5%) as well as between professional competence and digital literacy (41.6%). These findings suggest that professional development initiatives should extend beyond short-term training programs by emphasizing continuous mentoring, collaborative professional learning, and competency-based development to strengthen teachers' literacy, numeracy, and instructional capacities.

The quality of teacher–student interaction and pedagogy also emerged as a key dimension influencing students' literacy and numeracy competencies. Across the reviewed studies, this dimension reflects two complementary aspects of effective teaching: relational pedagogy, which emphasizes emotional support and positive teacher–student relationships, and intentional pedagogy, which focuses on structured, purposeful, and goal-oriented learning experiences.

Siraj et al. (2023) demonstrated that integrating relational and intentional pedagogy significantly enhanced teaching quality, with the SSTEW subscale for building trust, confidence, and independence increasing from 5.03 to 5.56 ($p<0.05$). These improvements were accompanied by positive gains in children's language, early numeracy, and socio-emotional development. Similarly, Wolf et al. (2019) found that interaction-focused teacher training in Ghana improved children's executive function (EF) and academic achievement, with EF serving as a mediating mechanism between teacher training and literacy and numeracy outcomes ($\beta=0.06–0.09$). Supporting these findings, Hartika et al. (2022) reported that the Structural Synthetic Analytics (SAC) approach, incorporating learning readiness activities such as clapping, singing, storytelling, and level-appropriate instruction, improved students' reading and numeracy performance, as reflected by teacher and student observation scores of 78 and 75, respectively, both categorized as good.

Collectively, these studies indicate that high-quality teacher–student interaction is not limited to positive interpersonal relationships but also requires carefully planned instructional practices that actively support students' cognitive development. The evidence suggests that relational pedagogy creates emotionally supportive learning environments that foster students' confidence and engagement, whereas intentional pedagogy ensures that learning activities are systematically organized to achieve measurable literacy and numeracy outcomes.

Furthermore, the reviewed studies consistently highlight Executive Function (EF) as an important mechanism linking instructional quality with academic achievement. Wolf et al. (2019) demonstrated that supportive classroom interactions first strengthen children's cognitive capacity before improving literacy and numeracy performance. Likewise, Siraj et al. (2023) and Hartika et al. (2022) emphasized that meaningful learning occurs when emotional support is integrated with structured instructional strategies. These findings suggest that teacher professional development should not only strengthen instructional competence but also develop teachers' abilities to establish emotionally supportive classroom environments that promote both cognitive and socio-emotional development.

The curriculum and learning approaches represent another important dimension influencing students' literacy and numeracy competencies. The reviewed studies consistently identify curriculum implementation, Contextual Teaching and Learning (CTL), Project-Based Learning (PjBL), ethnomathematics, and digital learning resources as complementary approaches that strengthen students' conceptual understanding and higher-order thinking skills.

Rosnelli and Ristiana (2023) found that implementation of the Independent Curriculum improved students' literacy and numeracy across scientific, digital, financial, and civic literacy domains, although differences were observed according to gender rather than school status. Siregar et al. (2025), through a literature review, concluded that literacy and numeracy are most effectively strengthened when integrated through contextual learning materials, Project-Based Learning, and the Independent Curriculum, enabling students to develop analytical thinking and conceptual understanding simultaneously. Likewise, Iswara et al. (2022) demonstrated that ethnomathematics, which connects mathematics with historical buildings, traditional games, and market activities, enhanced elementary students' numeracy literacy, particularly in geometry and measurement (Level 1), while producing moderate achievement in numbers (Level 2) and algebra (Level 3). Huda et al. (2024) further demonstrated through experimental research that mathematics e-modules significantly improved students' numeracy literacy ($p=0.002$; N-Gain=0.4). Similarly, Samad & Nur (2024) reported an increase of 35.87 points in students' numeracy literacy after implementing the Problem-Based Learning (PBL) model.

Taken together, these findings demonstrate that curriculum effectiveness depends not only on curriculum design itself but also on the instructional approaches used during implementation. Contextual learning, project-based activities, ethnomathematics, digital modules, and problem-based learning all contribute to making abstract concepts more meaningful by connecting learning with authentic experiences. Rather than functioning independently, these approaches complement one another in supporting literacy and numeracy development across different educational contexts.

The reviewed studies also indicate that curriculum implementation should be adaptive to students' learning characteristics and subject content. Rosnelli and Ristiana (2023) identified gender differences in students' responses to the Independent Curriculum, while Iswara et al. (2022) showed that ethnomathematics was more effective for concrete mathematical topics than for abstract algebraic concepts. These findings suggest that curriculum implementation should incorporate differentiated instructional strategies, combining contextual, cultural, technological, and problem-based approaches according to students' needs and learning objectives to maximize literacy and numeracy outcomes.

The use of technology and learning media emerged as another important dimension influencing students' literacy and numeracy competencies. Across the reviewed studies, this dimension encompasses digital learning media, gamification, augmented reality (AR), artificial intelligence (AI), e-modules, instructional videos, board games, and website-based microlearning. Despite their diversity, these interventions share a common objective of enhancing student engagement, facilitating conceptual understanding, and supporting more personalized learning experiences.

Anggun et al. (2025), through a systematic literature review of 25 studies, reported that gamification, augmented reality, and adaptive learning platforms increased student engagement by up to 80% and improved literacy and numeracy concept understanding by 25–40%, particularly when integrated with project-based learning and personalized instructional strategies. Similarly, Winarni et al. (2021) demonstrated that mathematics learning videos effectively improved students' numeracy and digital literacy competencies. At the teacher level, Achmad, Utami, & Idrus (2025) showed that Deep Learning-based artificial intelligence enhanced elementary school teachers' literacy competencies by providing adaptive feedback, facilitating professional reflection, and accelerating literacy mastery, thereby positioning AI as a pedagogical partner rather than merely a technological tool.

The reviewed studies further indicate that technology-enhanced learning is not limited to sophisticated digital innovations. Annazhira et al. (2025) demonstrated that interactive board games effectively stimulated students' interest in literacy activities by combining visual presentation with game-based learning. Likewise, Suardina et al. (2026) found that website-based microlearning significantly improved students' critical reasoning and contextual problem-solving abilities in fraction learning, with a determination coefficient of 47.5% for students' numeracy literacy skills. These findings suggest that both high-technology and low-technology learning media can effectively improve literacy and numeracy when they actively engage learners and are aligned with instructional objectives.

Overall, the evidence demonstrates that technology functions as an accelerator rather than a substitute for effective pedagogy. High-technology innovations such as AI, augmented reality, and adaptive learning platforms provide opportunities for personalized instruction and professional development, whereas instructional videos, board games, and microlearning platforms remain highly effective for strengthening foundational literacy and numeracy skills. Collectively, the reviewed studies indicate that the educational

value of technology depends less on its sophistication than on its pedagogical integration, contextual relevance, and sustainability within everyday classroom practice.

The learning environment at home and school also emerged as a significant dimension influencing students' literacy and numeracy competencies. This dimension includes home literacy and numeracy practices, parental support, the availability of learning resources, socioeconomic conditions, and cultural influences that collectively shape children's learning experiences beyond the classroom.

Novita et al. (2024) found that numeracy was closely associated with children's vocabulary development, with home numeracy activities and specific preschool literacy activities serving as significant predictors of vocabulary skills. Similarly, Moruk & Sulisworo (2024), through a longitudinal literature review, concluded that the home learning environment, parental education, and children's social-emotional skills collectively influence numeracy development. Their findings further indicate that socioeconomic status (SES) affects numeracy indirectly through the quality of the home literacy and numeracy environment, highlighting the mediating role of family learning practices. A cross-country study (2025) likewise demonstrated a consistent relationship between the home learning environment and students' academic achievement while emphasizing that cultural differences shape literacy and numeracy practices across countries. Novita et al. (2024) further reinforced these findings by showing that home numeracy activities and preschool literacy experiences significantly predict vocabulary development, reflecting the close interrelationship between literacy and numeracy during early childhood.

Collectively, these findings indicate that the home and school learning environment serves as a mediating mechanism linking broader structural factors with students' literacy and numeracy outcomes. Rather than directly determining academic achievement, socioeconomic status, parental education, and cultural background influence children's learning through the quality of literacy and numeracy experiences provided within the home environment. The reviewed studies consistently demonstrate that literacy and numeracy develop synergistically when children receive continuous cognitive stimulation across both home and school settings.

Furthermore, the evidence suggests that strengthening literacy and numeracy requires educational policies that extend beyond classroom instruction by actively engaging families and communities. Creating supportive home literacy environments, encouraging parental involvement, and ensuring access to meaningful learning resources can complement school-based interventions and contribute to more equitable literacy and numeracy development across diverse socioeconomic and cultural contexts.

School management and teacher collaboration constitute the final dimension influencing students' literacy and numeracy competencies. Unlike the previous dimensions, which primarily focus on classroom-level practices, this dimension emphasizes the organizational capacity of schools to create supportive conditions for sustainable instructional improvement. Effective leadership, collaborative professional culture, and coordinated school management enable teachers to implement innovative pedagogical practices more consistently and effectively.

Siraj et al. (2023) demonstrated that leadership-oriented professional development significantly improved teaching quality by strengthening collaboration among early childhood educators and school leaders. The Leadership for Learning programme enhanced teachers' instructional practices while simultaneously fostering a shared commitment to improving children's literacy and numeracy development. Likewise, Wolf et al. (2019) emphasized that sustained improvements in instructional quality require institutional support through continuous coaching, professional collaboration, and school-level capacity building rather than isolated teacher training initiatives.

The reviewed studies consistently indicate that school management functions as an enabling factor that strengthens the effectiveness of other dimensions of learning quality. Professional development programmes, curriculum implementation, technology integration, and innovative pedagogical practices are more likely to be sustained when supported by collaborative leadership, effective organizational management, and continuous professional learning communities. Consequently, improving literacy and numeracy should be viewed as a whole-school responsibility rather than solely an individual teacher's task.

The thematic synthesis of the reviewed studies demonstrates that learning quality is a multidimensional construct comprising six interconnected dimensions: teacher competence and professional development, teacher–student interaction and pedagogy, curriculum and learning approaches, technology and learning media, learning environment at home and school, and school management and teacher collaboration. Rather

than operating independently, these dimensions interact dynamically to shape students' literacy and numeracy competencies across different educational contexts.

Among these dimensions, teacher competence and professional development appear to function as the central catalyst linking the remaining dimensions. Teachers translate curriculum into classroom practice, determine how technology is integrated into instruction, establish meaningful teacher–student interactions, collaborate with school leadership, and engage families in supporting students' learning. Consequently, improvements in curriculum, educational technology, or school management are unlikely to produce optimal outcomes without competent teachers capable of implementing these resources effectively.

The reviewed evidence further suggests that technology, curriculum, home learning environments, and school management should not be interpreted as isolated determinants of literacy and numeracy achievement. Instead, these dimensions reinforce one another through reciprocal relationships. For example, technology becomes more effective when integrated into appropriate pedagogical practices, curriculum implementation depends on teachers' instructional competence, and supportive home environments amplify learning experiences initiated at school. Likewise, collaborative school leadership creates organizational conditions that enable teachers to continuously improve their instructional practices. These findings highlight that learning quality should be understood as a comprehensive educational ecosystem rather than a collection of independent variables.

This integrated perspective extends previous discussions of learning quality by demonstrating that literacy and numeracy development results from the interaction of instructional, organizational, technological, and environmental factors. Accordingly, educational improvement initiatives should adopt systemic approaches that simultaneously strengthen teacher competence, instructional quality, curriculum implementation, technological integration, family engagement, and collaborative school leadership.

Although previous studies have extensively examined individual factors affecting literacy and numeracy, the existing literature remains fragmented. Most empirical studies focus on single interventions, such as teacher professional development, curriculum implementation, digital learning media, or parental involvement, without examining how these factors interact within a comprehensive learning quality framework. Consequently, the current body of evidence provides limited understanding of the multidimensional relationships that collectively shape students' literacy and numeracy competencies.

Furthermore, existing systematic reviews generally concentrate on specific educational interventions or technologies rather than synthesizing the broader dimensions of learning quality. As a result, there is still limited conceptual integration explaining how instructional, organizational, technological, and environmental factors complement one another in improving literacy and numeracy outcomes, particularly within developing-country contexts.

This review contributes to the existing literature by synthesizing empirical evidence from diverse educational contexts into an integrated framework consisting of six interconnected dimensions of learning quality. Rather than viewing literacy and numeracy improvement as the result of isolated educational interventions, this review demonstrates that sustainable learning outcomes emerge through the interaction of teacher competence, instructional practices, curriculum implementation, technology integration, supportive learning environments, and collaborative school management.

The findings provide both theoretical and practical contributions. Theoretically, this review offers a more comprehensive understanding of learning quality as a multidimensional educational ecosystem in which teacher competence serves as the central catalyst connecting other dimensions. Practically, the proposed framework provides policymakers, school leaders, and educators with evidence-based guidance for designing integrated strategies that strengthen literacy and numeracy through coordinated improvements across multiple aspects of educational quality.

Conclusions

This systematic literature review concludes that learning quality plays a fundamental role in improving students' literacy and numeracy competencies across diverse educational contexts. The synthesis of the reviewed studies demonstrates that learning quality should be understood as a multidimensional and interconnected process in which teacher competence, instructional practices, curriculum implementation, technology integration, home learning environments, and school support collectively contribute to students'

learning outcomes. Rather than functioning as separate elements, these aspects reinforce one another in creating meaningful and sustainable improvements in literacy and numeracy.

The findings of this review further indicate that teacher competence and professional development serve as the key enabling factor that strengthens the implementation of other aspects of learning quality. Competent teachers facilitate effective curriculum implementation, create meaningful classroom interactions, integrate technology appropriately, and foster collaboration among schools and families. These findings highlight that improving literacy and numeracy cannot rely on isolated educational interventions but requires a comprehensive approach that addresses multiple dimensions of learning quality simultaneously.

This review contributes by synthesizing fragmented empirical evidence into a coherent understanding of how learning quality influences literacy and numeracy development across different educational settings. The findings provide a conceptual reference for educators, school leaders, and policymakers in designing more integrated strategies to improve learning quality while also offering a foundation for future empirical studies examining the relationships among the identified aspects of learning quality.

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