The Landscape of Early Numeracy Skills Research in Indonesia: A Systematic Literature Review

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Abstrak

Literasi numerasi pada anak usia dini merupakan keterampilan dasar yang penting untuk mendukung perkembangan kognitif dan akademik anak. Namun, penelitian di Indonesia masih bersifat beragam dan belum terintegrasi. Penelitian ini bertujuan untuk menganalisis tren publikasi, mengidentifikasi strategi yang diterapkan, serta mengkaji dampak intervensi literasi numerasi anak usia dini di Indonesia pada periode 2016–2025. Penelitian ini menggunakan metode systematic literature review (SLR) dengan kerangka PRISMA. Sebanyak 20 artikel dari jurnal nasional yang terbit pada tahun 2016–2025 dipilih dari database Google Scholar dan Dimensions berdasarkan kriteria inklusi, yaitu penelitian yang berfokus pada peningkatan literasi numerasi anak usia dini, dilakukan di Indonesia, dan tersedia dalam akses teks lengkap. Data dianalisis menggunakan analisis tematik untuk mengidentifikasi tren penelitian, pendekatan pembelajaran, dan hasil intervensi yang dominan. Hasil penelitian menunjukkan adanya pergeseran dari pembelajaran berbasis keterampilan prosedural menuju pendekatan yang lebih terintegrasi, berbasis bermain, kontekstual, dan berorientasi pada konsep. Strategi yang dominan meliputi pembelajaran berbasis bermain, penggunaan media manipulatif dan konkret, serta aktivitas kontekstual yang secara konsisten menunjukkan dampak positif terhadap kemampuan numerasi, keterlibatan belajar, kemampuan pemecahan masalah, dan perkembangan anak secara menyeluruh. Kesimpulannya, pendekatan pembelajaran yang interaktif dan berpusat pada anak terbukti efektif dalam mendukung perkembangan literasi numerasi anak usia dini di Indonesia..

Kata Kunci: *numeracy skills, early childhood, literacy numeracy*

Abstract

Early childhood numeracy literacy is a fundamental skill that supports children's cognitive and academic development. However, studies on numeracy literacy in Indonesia remain fragmented and have not been comprehensively synthesized. This study aimed to analyze publication trends, identify instructional strategies, and examine the effectiveness of interventions used to improve early childhood numeracy literacy in Indonesia during 2016–2025. This study employed a systematic literature review (SLR) using the PRISMA framework. A total of 20 articles published in national journals during 2016-2025 were selected from the Google Scholar and Dimensions databases based on predetermined inclusion criteria, which included studies focusing on improving early childhood numeracy literacy, conducted in Indonesia, and available in full-text access. Data were analyzed using thematic analysis to identify major research trends, instructional approaches, and intervention outcomes. The findings indicate a shift from procedural and skill-based instruction toward more integrated, play-based, contextual, and concept-oriented approaches. The dominant strategies included play-based learning, the use of manipulative and concrete media, and contextual learning activities, which consistently demonstrated positive effects on children's numeracy skills, engagement, problem-solving abilities, and overall development. The study concludes that interactive and child-centered learning approaches are highly effective in supporting the development of early childhood numeracy literacy in Indonesia.

Keyword: *numeracy skills, early childhood, literacy numeracy*

INTRODUCTION

Numeracy is not limited to the ability to perform basic mathematical operations; rather, it encompasses the capacity to apply mathematical reasoning and problem-solving skills in various real-life contexts. Kemendikbud (2021) stated that numerical literacy consists of mathematical components such as numbers, measurement, geometry, algebra, and data analysis. Children who have a strong foundation in numerical literacy during early childhood tend to be better prepared and more confident in mastering more complex materials in the future. Because of its important role in supporting academic achievement and everyday decision-making, numeracy has increasingly been recognized worldwide as an essential competency for lifelong learning and participation in modern society. In line with this global concern, the issue of numerical literacy has gained significant attention in Indonesia, as it is recognized as a fundamental competency for students to participate in the demands of the 21st century.

Despite the growing recognition of numeracy as an essential competency, many young children still experience difficulties in understanding number concepts, mathematical reasoning, and problem-solving skills during early childhood education. Ideally, early numeracy learning should support children's conceptual understanding through meaningful, play-based, and contextual experiences. However, classroom practices in many contexts, including Indonesia, still tend to emphasize procedural counting, memorization, and worksheet-based activities rather than conceptual exploration. Wahyuni (2020) observed 15 children aged 5–6 years; out of 15 children, 7 children still made mistakes in counting and writing numbers, such as writing numbers in reverse or mixing up number names. Hayati & Fitri (2016) observed that 7 out of 10 children aged 3–4 years who were research samples often made mistakes when counting objects presented to them; the counts did not match their verbal utterances. Simatupang et al. (2023) also observed that most children aged 5–6 years still had difficulty using number symbols for counting.

Recent international studies have highlighted the importance of developmentally appropriate and inquiry-based numeracy learning in fostering children's mathematical thinking and long-term academic achievement. For example, Dierkx et al. (2025) found that early numeracy development strongly predicts later mathematics achievement, while Torres-Peña et al. (2025) emphasized that contextual problem-solving activities enhance preschool children's mathematical thinking.

Children are in the stage of informal numeracy, where they are able to count sequentially and recognize the properties of objects. These abilities develop into the formal stage at primary school, which explores more abstract concepts such as arithmetic operations. The transition from informal to formal numeracy often becomes a critical challenge in early childhood education, as children are required to move from concrete experiences toward a more symbolic and abstract understanding of numbers. As a result, problems in teaching number sense in early childhood frequently arise from children's low ability to understand number concepts because the instruction is often delivered in an abstract manner. Another factor is that teachers and parents tend to rely only on finger counting from 1 to 10 and limit learning activities to worksheets, which results in children having limited familiarity to understanding number concepts.

Improving numerical literacy skills in early childhood education can be achieved by applying teaching methods that align with the children's characteristics and needs. Previous studies have shown that developmentally appropriate practices, such as interactive play, manipulative-based activities, and contextual learning experiences, can effectively support young children's understanding of numeracy concepts and problem-solving skills. Chopra (2025) further emphasized that developmentally appropriate activities encourage children's learning through active exploration, hands-on experiences, and meaningful interaction with their environment rather than through rigid academic instruction. Rahmawati et al. (2024) also highlighted that play-based learning environments support the development of children's problem-solving abilities by allowing them to explore, make mistakes, and learn through trial-and-error experiences in a low-pressure setting.

To determine whether strategies used by early childhood educators in Indonesia are effective in improving children's numeracy skills, this study conducted a systematic literature review (SLR) on strategies to improve children's numeracy skills in Indonesia from 2016 to 2025. The study focuses on media, models, techniques, and methods used to improve children's numerical literacy skills. We hoped that this study could serve as a reference to understand the extent of educational stakeholders' efforts

to improve numeracy literacy at the ECE level in Indonesia. As stated by Via & Setiyatna (2023), educational evaluation is necessary to determine the quality of institutions and learners' achievements, where assessment assists educators in analyzing students' progress and performance, as well as determining subsequent actions. Thus, this study is expected to provide a synthesis of the efforts undertaken to enhance early childhood numeracy literacy in Indonesia during 2016–2025.

METHOD

This study employed a Systematic Literature Review (SLR) design to identify, evaluate, and synthesize research findings related to strategies for improving early childhood numerical literacy skills in Indonesia during 2016-2025. The review process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a transparent and systematic article selection process. In addition, the PICOS framework (Population, Intervention, Comparison, Outcomes, Study design) was used to formulate the research focus and determine the inclusion criteria.

This study aims to answer the following research questions:

Table 1. Research Questions

Authors	Numerical Literacy Skills Research Focus
RQ 1	What are the trends in publications related to children's numerical literacy skills in Indonesia within the period 2016–2025?
RQ 2	What programs or strategies have been implemented in Indonesia to improve children's numerical literacy skills during the period 2016–2025?
RQ 3	How effective are these strategies in improving children's numerical literacy skills?

The PICOS framework was used to determine the eligibility criteria and scope of the review.

- Population (P): Early childhood learners in Indonesia (PAUD, TK, RA, SPS, KB)
- Intervention (I): Any strategies, methods, media, models, techniques, or approaches aimed to improve children's numerical literacy skills
- Comparison (C): Not strictly required, but studies with or without comparison groups were included
- Outcomes (O): Improvement in early numerical skills (e.g., counting, number recognition, problem-solving)
- Study design (S): Empirical studies including classroom action research, experimental, quasi-experimental, and qualitative studies.

The Articles were collected from two major academic databases, Dimensions and Google Scholar, using the keyword string "*anak usia dini AND ('literasi numerasi' OR 'angka' OR 'bilangan')*". The search was limited to publications between 2016 and 2025.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria in this study are presented in Table 2.

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
● Articles published in national academic journals between 2016 and 2025	● Conference proceedings, thesis, book chapters, and opinion articles
● Studies focusing on improving children's numerical literacy skills	● Articles unrelated to numeracy literacy
● Research conducted in Indonesia	● Studies focusing on primary school or higher education levels
● Full-text articles accessible	● Articles with incomplete research methods or findings

The article screening process was conducted in several stages based on the PRISMA framework. First, all identified articles from the databases were collected and checked for duplication. In this stage,

we identified a total of 1142 articles, 506 articles from Google Scholar and 636 from Dimensions. 553 duplicate articles were removed before the screening stage, with 589 articles remaining for the screening.

Second, the titles and abstracts were reviewed to determine their relevance to the research topic. Third, full-text screening was conducted to assess whether the articles met the inclusion criteria. 201 articles met the inclusion criteria after screening. Considering the exploratory nature of this review and the need for in-depth thematic analysis, purposive sampling was applied to obtain representative studies from each publication year. The selection process also aimed to ensure temporal representation across publication years and variation in instructional approaches, prioritized articles that offered rich and detailed findings related to children numerical literacy skills improvement. This process resulted in a final sample of 20 articles for in-depth analysis.

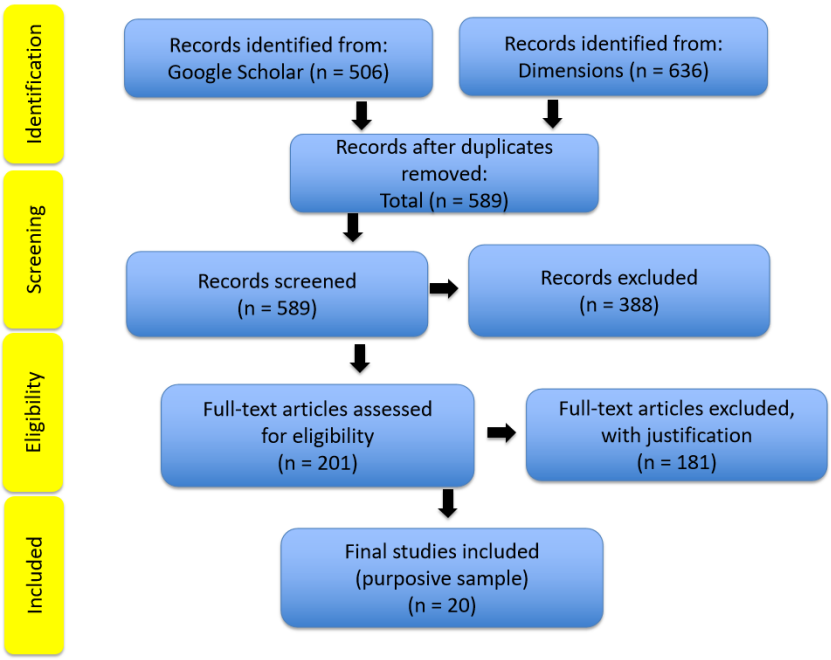

Figure 1. PRISMA Flow Diagram

The screening and selection process involved two independent reviewers. Each reviewer evaluated the articles separately to minimize bias. In cases of disagreement regarding article eligibility, discussions were conducted until consensus was reached. If disagreement persisted, a third reviewer assisted in making the final decision.

To ensure the quality of the selected studies, a quality appraisal process was conducted using criteria adapted from systematic review guidelines. The assessment focused on the clarity of research objectives, appropriateness of methodology, data collection procedures, validity of findings, and relevance to the research topic. Articles categorized as having low methodological quality were excluded from the final review.

Data Analysis

The selected articles were analyzed using thematic synthesis techniques. The analysis process involved several stages. First, extracting important information from each study (authors, year of publication, participants, methods, interventions, findings) to identify trends in publication, methodological patterns, types of interventions, and reported impacts on numeracy literacy. Second, coding similar themes related to numeracy learning strategies and categorizing the findings into broader themes such as learning media, play-based methods, instructional models, and technology-based approaches. The findings were then synthesized to address the three research questions regarding publication trends, implemented strategies, and the impacts of these interventions on early childhood numeracy literacy in Indonesia.

RESULT AND DSICUSSIONS

Result

Trends in Early Childhood Numerical Literacy Research

The findings indicate a significant shift in focus and conceptualization of early childhood numeracy literacy research in Indonesia between 2016 and 2025. Early studies conducted during 2016-2018 predominantly focused on basic numeracy skills, such as counting, number recognition, and simple arithmetic operations (Romlah et al., 2016; Wulan et al., 2017). The primary objective of these studies was to improve children's procedural competence, which was commonly measured through counting accuracy and symbol recognition activities. Learning strategies implemented during this period mainly involved repetitive practice, instructional games, and manipulative media.

However, studies published from 2019 onwards demonstrate a transition toward conceptual understanding and contextual application of numeracy skills. For example, Sumawardani et al. (2019) reported that outdoor learning improved not only counting skills but also children's ability to relate numbers to real-world objects. Similarly, Rohmalina et al. (2020) found that open-ended approaches significantly enhanced children's problem-solving abilities, indicating a shift toward higher-order thinking.

Furthermore, studies conducted after 2022 conceptualized numeracy literacy as a broader and more multidimensional competency. Recent research increasingly integrates mathematical domains such as geometry, measurement, spatial reasoning, and analytical thinking into early childhood learning activities (Adawiyah & Priyanti, 2023; Nurhayati et al., 2024). In addition, researchers also implemented more child-centered and contextual learning approaches, including project-based learning, loose-part media, and multimodal learning environments.

Table 3. Numerical Literacy Skills Research Focus in Indonesia

Period of Publication	Authors	Main Research Focus
2016-2017	Achmadi (2017); Romlah et al. (2016); Sugiono & Kuntjojo (2016); Wulan et al. (2017)	• Basic numeracy literacy skills • Counting • Number recognition • Simple arithmetic • Instructional games
2018-2019	Agustin (2018); Muliani (2019); Savitri (2018); Sumawardani et al. (2019)	• Number concepts • Cognitive numeracy • Contextual learning • Play-based activities
2020-2021	Anggraini & Irsyad (2021); Bachtiar (2021); Rohmalina et al. (2020); Setyaningtyas & Harun (2020)	• Conceptual understanding • Open-ended learning • Brain-based learning
2022-2023	Adawiyah & Priyanti (2023); Amaliah et al. (2023); Citra et al. (2022); Rambe & Konadi (2022)	• Integrated numeracy literacy • Cognitive development • Innovative media
2024-2025	Aliyah & Nurajizah (2025); Antika & Hikmah (2024); Humairoh (2025); Nurhayati et al. (2024)	• Holistic numeracy • Geometry • Measurement • Project-based learning • Multimodal learning

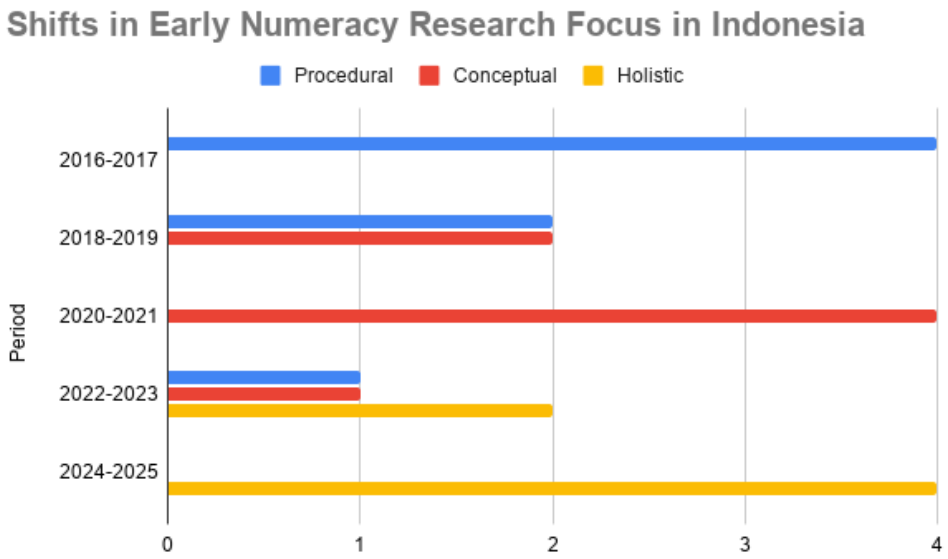

Figure 2. Shift in Early Numeracy Research Focus in Indonesia

In addition to the shift in research focus, the reviewed studies also demonstrate notable methodological developments across publication periods. As researchers increasingly explored conceptual understanding and contextual learning experiences, more diverse methodological approaches began to emerge in early childhood numeracy research. Earlier studies predominantly relied on quantitative and classroom-based intervention designs to measure improvements in procedural skills. In contrast, recent studies increasingly incorporated qualitative and mixed-method approaches to explore conceptual understanding and contextual learning processes.

Table 4. Distribution of Methods

Methods	2016-2017	2018-2019	2020-2021	2022-2023	2024-2025
Classroom Action Research (CAR)	2	3	2	0	2
Experimental or Quantitative	1	1	2	3	1
Descriptive Qualitative	0	0	0	1	1
Research & Development (R&D)	1	0	0	0	0

As shown in Table 3, Classroom Action Research (CAR) and quantitative approaches dominated numeracy literacy research during the earlier publication periods, particularly between 2016 and 2021. These studies primarily focused on evaluating the effectiveness of instructional interventions and improving children's procedural numeracy skills within classroom settings.

However, studies published after 2022 demonstrate increasing methodological diversity, including the emergence of qualitative and mixed-method approaches. This shift indicates growing attention toward understanding children's conceptual learning processes, contextual experiences, and holistic numeracy development rather than solely measuring procedural achievement outcomes.

Despite this methodological diversification, Classroom Action Research remains one of the most frequently used approaches due to its practicality in evaluating instructional strategies directly within authentic early childhood classroom contexts. The methodological progression also reflects the broader conceptual transformation of numeracy literacy research in Indonesia from procedural skill acquisition toward integrated, contextual, and child-centered learning perspectives.

Strategies Implemented in Indonesia to Improve Children's Numerical Literacy Skills

The findings reveal that play-based, media-supported, and child-centered strategies dominate early childhood numeracy literacy programs in Indonesia.

Play-Based Learning

Play-based learning approaches emerge as the most dominant strategy across the reviewed studies. Many interventions utilize structured and semi-structured games to introduce and reinforce numeracy concepts. Examples include the use of an abacus (sempoa), number sticks, dice games, bowling games, and role-playing activities such as buying and selling. These play-based strategies are designed to make learning more engaging and meaningful for children by embedding mathematical concepts within enjoyable activities. Romlah et al. (2016) demonstrated that abacus-based play significantly improved counting skills, while Agustin (2018) showed that dice games reduced the proportion of children with low numeracy ability. Similarly, Wulan et al. (2017) reported that number stick media increased achievement to 90.9% by the final intervention cycle. The findings show that such approaches are consistently applied throughout the entire period, indicating their central role in early childhood numeracy education in Indonesia.

a. Manipulatives and Concrete Media

The use of concrete learning media is another dominant strategy. A wide variety of concrete learning materials are employed, including flashcards, number cards, blocks, puzzles, loose parts, and associative image media. These materials are often used to support children's understanding of number symbols, counting, classification, and basic operations. In earlier studies, the media were simple and teacher-prepared, such as number sticks or printed cards. Number cards and block media were found to significantly improve children's understanding of number symbols and counting concepts (Amaliah et al., 2023; Anggraini & Irsyad, 2021). However, in more recent studies, there is a noticeable shift toward more diverse and flexible materials, such as loose parts (e.g., beads, buttons, recycled materials) that allow children to explore multiple mathematical concepts simultaneously. Adawiyah & Priyanti (2023) found that loose parts improved multiple aspects of numeracy, including classification and spatial reasoning, while Aliyah & Nurajizah (2025) reported 100% achievement in numeracy indicators after implementation. This evolution reflects a move from structured manipulatives to exploratory learning tools, supporting deeper conceptual understanding.

Innovative Pedagogical and Contextual Learning

Several studies implement innovative pedagogical models aimed at enhancing numeracy literacy. These include approaches such as brain-based learning, open-ended learning, and project-based learning. Brain-based learning strategies involve structured stages such as pre-exposure, elaboration, and integration, designed to align with how children naturally process information. Open-ended approaches encourage children to explore multiple solutions to mathematical problems, fostering critical thinking and creativity. Meanwhile, project-based learning engages children in longer-term activities that integrate numeracy with real-life contexts, such as measuring, counting, and constructing objects. Setyaningtyas & Harun (2020) reported a large effect size for brain-based learning, indicating a strong cognitive impact. Similarly, Nurhayati et al. (2024) showed that project-based learning increased mean numeracy scores from 2.3 to 3.8.

The findings highlight the importance of integrated and contextual learning approaches. Several studies combine numeracy learning with real-life contexts and other developmental domains. For example, Sumawardani et al. (2019) suggest that outdoor learning activities allow children to count, classify, and measure objects in their natural environment, thereby making learning more meaningful. Similarly, Rambe & Konadi (2022) enhance learning by linking numeracy to real-life

experiences using role-playing activities, such as simulated market transactions, to help children understand number concepts through social interaction and practical application.

Although they are less prevalent compared to other approaches. Some studies also use digital tools such as PowerPoint presentations to support storytelling and introduce number concepts (Savitri, 2018). Using PowerPoint is found to be more effective than traditional learning because this method could enhance children's visual engagement and provide more structured learning experiences.

The analysis also reveals that most programs and strategies follow a structured sequence of instructional steps. Typically, these include (1) introduction of concepts through demonstration or storytelling, (2) guided practice using media or games, (3) independent or group activities, and (4) evaluation through observation or performance tasks. This structured approach is particularly evident in classroom action research studies, where interventions are implemented in cycles to continuously improve learning outcomes.

Furthermore, the strategies implemented are closely aligned with the developmental characteristics of young children. Many studies emphasize the importance of hands-on activities, repetition, visual aids, and social interaction in facilitating numeracy learning. The use of concrete objects and real-life contexts is particularly prominent, reflecting the need to bridge abstract mathematical concepts with children's everyday experiences.

Another notable trend is the increasing diversity of strategies over time. While early studies rely heavily on simple games and direct instruction, later studies incorporate more complex and integrative approaches, such as combining multiple media, using interdisciplinary methods, and designing learning environments that promote exploration and inquiry. This indicates a gradual shift toward more sophisticated and holistic instructional practices.

Effectiveness of The Strategies Implemented on Children's Numerical Literacy Skills

The findings of the reviewed studies consistently indicate that the implemented strategies had positive effects on children's numeracy literacy development. Overall, the studies reported improvements in counting ability, number recognition, symbol identification, conceptual understanding, and problem-solving skills after the implementation of various instructional interventions. Almost all intervention-based studies report measurable gains in these foundational skills, as evidenced by statistical analyses such as t-tests, pretest–posttest comparisons, and descriptive percentage increases. For example, Achmadi (2017) found a significant improvement ($t = 8.295$), while Muliani (2019) reported an increase in mastery from 61.11% to 94.44%. These findings suggest that the interventions are particularly effective in addressing early difficulties in counting, symbol recognition, and number sequencing.

Beyond basic skills, the findings reveal improvements in higher-order cognitive and problem-solving abilities related to numeracy. Several studies report that children demonstrate better understanding of number concepts, including classification, comparison, ordering, and one-to-one correspondence. Interventions such as open-ended learning, brain-based learning, and project-based learning contribute to the development of children's reasoning and problem-solving skills (Adawiyah & Priyanti, 2023; Rohmalina et al., 2020). Children were able to apply numeracy concepts in different contexts, identify patterns, and develop strategies to solve mathematical problems. Some studies also report large effect sizes, indicating a strong impact of the interventions on children's cognitive development.

The results indicate a substantial increase in children's engagement, motivation, and participation during learning activities. Many studies highlight that the use of play-based approaches, interactive media, and contextual learning environments makes numeracy learning more enjoyable and meaningful for children. Rohmalina et al. (2020) noted increased enthusiasm in open-ended tasks, while Humairoh (2025) reported improved participation through interactive media. Observational data show that children become more active, enthusiastic, and confident in participating in learning activities. For example, children are more willing to answer questions, engage in group work, and complete assigned tasks. Increased motivation is also reflected in improved attention spans and persistence when solving problems. These findings suggest that the effectiveness of the interventions

is not only due to cognitive factors but also strongly influenced by affective and motivational aspects of learning.

Several studies report broader developmental impacts that support numeracy literacy, including improvements in social skills, communication, and self-confidence. Through collaborative activities such as group games, role-playing, and project-based tasks, children develop the ability to interact with peers, express their ideas, and work cooperatively. In addition, some studies note that children become more confident in demonstrating their abilities, such as presenting their work or participating in classroom discussions. There is also evidence that certain interventions, such as outdoor learning and contextual activities that foster children's awareness of their environment and their ability to apply numeracy skills in real-life situations (Rambe & Konadi, 2022; Sumawardani et al., 2019). These broader outcomes highlight the interconnected nature of numeracy literacy with other domains of early childhood development.

In terms of measurement, the impacts are assessed using a variety of methods, including standardized tests, performance assessments, observational checklists, and qualitative documentation. Quantitative studies commonly report statistically significant improvements. Meanwhile, qualitative studies provide detailed descriptions of changes in children's behavior, engagement, and learning processes. The combination of these assessment approaches strengthens the overall evidence of positive impacts.

Another important finding is the consistency of positive outcomes across different types of interventions. Whether using simple play-based activities, structured pedagogical models, or innovative media, most studies report improvements in numeracy literacy. However, interventions that incorporate multiple elements, such as combining play, media, and contextual learning tend to produce more comprehensive outcomes, including both cognitive and affective improvements. This suggests that integrated approaches may be more effective in supporting holistic numeracy development.

Furthermore, the results indicate that the magnitude of improvement often increases over time or across intervention cycles. In classroom action research studies, repeated cycles of planning, action, observation, and reflection lead to continuous improvement in children's performance. Similarly, longer or more intensive interventions, such as project-based learning implemented over several weeks, show more substantial gains compared to shorter interventions. This highlights the importance of sustained and iterative implementation in achieving optimal learning outcomes. Despite the overall positive findings, it is important to note that most studies are conducted on a relatively small scale, typically involving a single classroom or institution. Therefore, while the results demonstrate strong effectiveness at the micro level, further research may be needed to confirm their generalizability to broader populations.

Discussion

Conceptual Shifts in Numeracy Literacy

Consistent with the findings presented in the Results section, research on early childhood numeracy literacy in Indonesia demonstrates a clear shift from a skill-based orientation toward a more holistic and contextualized understanding of numeracy. Earlier studies included in this review primarily focused on procedural competencies such as counting, number recognition, and simple arithmetic operations. In contrast, more recent studies increasingly conceptualize numeracy as the ability to apply mathematical understanding in meaningful and real-life contexts through reasoning, problem-solving, and active exploration. This transition is reflected in the growing use of contextual learning, open-ended activities, and play-based approaches identified across the reviewed studies.

This finding aligns with international trends in mathematics education. Österman & Bråting (2019) reported that modern curricula in Sweden increasingly prioritize students' ability to explain mathematical reasoning, discuss strategies, and reflect metacognitively rather than merely perform calculations. Similarly, the reviewed Indonesian studies demonstrate increasing emphasis on conceptual understanding and contextual application rather than rote memorization alone. This conceptual shift reflects broader efforts to develop functional literacy and higher-order thinking skills needed in 21st-century learning contexts.

The findings of this review also reinforce the importance of strengthening numeracy literacy during early childhood. Several reviewed studies reported improvements not only in counting ability and number recognition, but also in problem-solving, reasoning, and conceptual understanding after implementing play-based and contextual learning strategies. These findings are consistent with Chen (2025), who emphasized that early mathematical skills, including number sense and pattern recognition, are strongly associated with later academic performance. Both initial numeracy skills and early growth significantly predict later mathematical achievement (Dierkx et al., 2025). This suggests that the interventions identified in this review may contribute to children's long-term mathematical development.

Furthermore, the reviewed studies indicate that contextual and constructivist learning approaches support children's higher-order thinking and meaningful engagement with mathematical concepts. Several studies included in this review showed that children demonstrated stronger problem-solving abilities when learning activities involved real-world situations, collaborative interaction, and concrete experiences. This finding supports Çibukçiu (2025), who argued that constructivist approaches emphasizing discussion, collaboration, and real-world problem-solving produce better learning outcomes than traditional teacher-centered instruction. Sujatha & Vinayakan (2023) also highlighted that integrating real-world contexts into mathematics learning enhances children's engagement, critical thinking, and conceptual understanding.

The findings also reveal that children's everyday experiences play an important role in numeracy development. Studies reviewed in this research frequently incorporated contextual activities such as role-playing, games, outdoor learning, and object manipulation to support mathematical understanding. This aligns with Jäder & Johansson (2025), who found that children typically rely on familiar contexts and representations during problem-solving processes. Connecting mathematics learning to children's everyday environments improved skills such as classification, pattern recognition, counting, and understanding basic arithmetic concepts (Torres-Peña et al., 2025). MacDonald (2022) further emphasized that children develop meaningful mathematical understanding through daily experiences such as shopping, cooking, playing games, and interacting with family members. Overall, the findings of this review suggest that numeracy literacy is increasingly understood as a multidimensional competency involving reasoning, communication, problem-solving, and meaningful engagement with mathematical ideas.

Effectiveness of Learning Strategies

The findings of this review reveal that play-based, media-supported, and child-centered strategies are central to improving early childhood numeracy literacy in Indonesia. Across the reviewed studies, play-based learning emerged as the most dominant instructional approach, with activities such as games, role-playing, outdoor learning, and guided exploration effectively embedding mathematical concepts in meaningful contexts, resulting in improvements in children's counting ability, number recognition, engagement, and problem-solving skills after the implementation (Agustin, 2018; Romlah et al., 2016; Wulan et al., 2017)

These findings align with international literature emphasizing the importance of play in early mathematics learning. Sarama & Clements (2025) argued that play and mathematics should not be viewed as separate domains because children naturally engage with mathematical concepts such as patterns, shapes, counting, spatial reasoning, and measurement during play activities. Similarly, Skalstad et al. (2025) highlighted the importance of teachers in creating curiosity and interest through varied and multisensory learning experiences. This perspective is further supported by Buldu & Buldu (2025), who found that teachers perceive playful learning as one of the most appropriate approaches for supporting children's development and learning.

The reviewed studies also indicate that guided play contributes positively to both engagement and conceptual understanding. Several interventions included teacher facilitation, questioning, and collaborative activities that encouraged children to actively construct mathematical understanding. This finding supports Louw & Claassens (2024), who emphasized that guided play enhances conceptual understanding and learning engagement. Likewise, Taylor & Boyer (2020) described adult-guided play as a balance between free play and direct instruction, where children retain autonomy during play while educators provide scaffolding and extend learning opportunities. This aligns with the

findings of this review, which demonstrate that teacher-supported play activities help children engage more meaningfully with mathematical concepts.

In addition to play-based learning, the reviewed studies demonstrate the effectiveness of instructional media and manipulatives in supporting numeracy literacy development. Several studies included in this review utilized concrete learning materials such as blocks, loose parts, flashcards, number sticks, and associative image media to facilitate children's understanding of mathematical concepts. Children performed significantly better when using tangible manipulatives compared to virtual ones (Nikiforidou, 2019). The increasing use of instructional media and manipulatives, including the shift toward flexible resources such as loose parts, also reflects constructivist principles. Manipulative materials accommodate diverse learning styles by supporting auditory, visual, and kinesthetic learning through explanation, demonstration, and hands-on engagement (Larbi & Mavis, 2016). It also serves as an important link between theoretical concepts and practical application, improving students' comprehension of mathematical concepts (Gnawali, 2025). These materials support children's transition from concrete experiences toward more abstract mathematical thinking.

The findings further suggest that numeracy learning is strengthened through social interaction and collaborative engagement. Several reviewed studies incorporated collaborative activities such as role-playing, group tasks, and discussion-based learning, which contributed to children's communication, confidence, and problem-solving abilities. This aligns with Ali et al. (2018), who conceptualized play as a multidimensional process involving physical, verbal, and mental engagement. The findings also reflect Lev Vygotsky's sociocultural theory, which emphasizes the importance of social interaction and guided support in children's cognitive development. For example, Rohmalina et al. (2020) found that open-ended learning activities significantly improved children's problem-solving abilities by encouraging exploration, discussion, and multiple solution strategies. Similarly, Sumawardani et al. (2019) reported that outdoor learning activities enabled children to connect mathematical concepts with real-world experiences, thereby strengthening conceptual understanding and engagement.

Collaborative learning activities were also found to support creativity, idea sharing, and active participation. However, the effectiveness of collaborative learning depends largely on teachers' competence in designing structured activities and providing appropriate guidance. Oktaviana et al. (2023) emphasized that teachers need to consider children's characteristics, learning styles, and classroom environments to ensure that collaborative learning activities are implemented effectively. Overall, the findings suggest that developmentally appropriate, interactive, and socially engaging learning environments are highly effective in supporting early childhood numeracy literacy development.

Practical and Policy Implications

The findings suggest that early childhood educators should increasingly implement play-based, contextual, and child-centered numeracy learning approaches that align with children's developmental characteristics. Strategies involving games, storytelling, outdoor activities, collaborative learning, and manipulative media appear to support children's engagement and conceptual understanding more effectively than worksheet-based instruction. These findings also highlight the importance of strengthening teacher professional development and improving access to developmentally appropriate learning resources to support holistic numeracy learning in Indonesian early childhood education settings.

This need is consistent with Sun et al. (2025), who emphasized that professional development helps teachers design conceptual, contextual, and inquiry-based mathematics learning rather than relying solely on rote memorization. Linder & Simpson (2018) found that although many teachers understand developmentally appropriate approaches such as play-based and open-ended learning, some still perceive mathematics as a fixed body of knowledge shaped by traditional instructional experiences. Therefore, continuous professional development is essential to strengthen both teachers' mathematical content knowledge and pedagogical practices.

The findings also suggest the importance of curriculum implementation that prioritizes conceptual understanding, reasoning, and contextual numeracy experiences over procedural counting skills alone. This is supported by Wu & Lee (2026), who compared traditional Chinese preschools and

Montessori preschools. Traditional Chinese preschools tended to emphasize teacher-directed instruction, memorization, and procedural understanding, whereas Montessori settings emphasized child-centered exploration, concrete manipulatives, and self-directed learning. These differences demonstrate how instructional approaches can shape children's opportunities to actively construct mathematical understanding.

In addition, the reviewed studies indicate that supportive learning environments play an important role in children's numeracy development. The study by Kurniawan et al. (2022) highlighted that family, school, peers, and community environments significantly influence children's motivation and learning outcomes. This finding aligns with Lev Vygotsky's sociocultural theory, which emphasizes that children learn most effectively through guided interaction and scaffolding provided by more knowledgeable others. As explained by Newman & Latifi (2021), these collaborative interactions within the Zone of Proximal Development support children in gradually developing independent thinking and problem-solving abilities.

Limitations and Recommendations for Future Research

Several limitations should be acknowledged in this review. The reviewed studies were limited to articles indexed in Google Scholar and Dimensions, which may have excluded relevant studies from other international databases. Second, most reviewed studies employed small-scale classroom interventions and Classroom Action Research designs, limiting the generalizability of findings across broader Indonesian early childhood education contexts. Third, variations in methodological quality and reporting standards across studies may affect the consistency and reliability of the synthesized findings. Future studies should employ larger and more diverse samples, longitudinal designs, and mixed-method approaches to provide stronger empirical evidence regarding the long-term effectiveness of numeracy interventions. Further research is also needed to explore digital numeracy learning, inclusive mathematics education, parental involvement, and culturally responsive approaches in Indonesian early childhood education settings.

CONCLUSION

This study aimed to examine research trends, instructional strategies, and the effectiveness of approaches used to improve early childhood numeracy literacy in Indonesia between 2016 and 2025. The findings demonstrate a clear shift from procedural and skill-based instruction toward more holistic, play-based, contextual, and child-centered approaches. Across the reviewed studies, strategies involving play-based learning, manipulative media, contextual activities, and innovative pedagogical approaches consistently showed positive effects on children's numeracy development, including counting ability, conceptual understanding, problem-solving skills, and higher-order thinking. The findings also indicate that numeracy literacy is increasingly conceptualized as a multidimensional competency that extends beyond basic arithmetic skills to include reasoning, communication, and the application of mathematical concepts in meaningful contexts. These results reinforce the importance of developmentally appropriate and experiential learning environments in supporting early childhood numeracy development. Practically, the findings suggest the need for greater support for play-based and contextual numeracy instruction in Indonesian early childhood education settings, including teacher professional development and the provision of appropriate learning media. Future research should employ larger-scale, longitudinal, and mixed-method designs to strengthen the evidence base and explore broader contexts of numeracy literacy development in Indonesia.

REFERENCES

Achmadi, A. (2017). Mengenalkan lambang bilangan melalui permainan menjatuhkan simbol angka pada anak usia *dini. Wahana: Tridarma Perguruan* Tinggi, 69(2), 39–43. https://doi.org/10.36456/wahana.v69i2.1067

Adawiyah, R., & Priyanti, N. (2023). Pemanfaatan media loose part untuk meningkatkan kemampuan literasi dan numerasi anak di TK Dharma Wanita Persatuan *Bawean. JIIP: Jurnal Ilmiah Ilmu* Pendidikan, 6(11), 9567–9574. https://doi.org/10.54371/jiip.v6i11.2411

Agustin, R. (2018). Upaya meningkatkan kemampuan berhitung melalui kegiatan bermain dadu papan angka ber*kelok. CERIA (Cerdas Energik Responsif Inovat*if Adaptif), 1(1), 23–30.

https://doi.org/10.22460/ceria.v1i1.p23-30
Ali, E., Kaitlyn, M. C., Hussain, A., & Akhtar, Z. (2018). The effects of play-based learning on early childhood education and development. *Journal of Evolution of Medical and Dental Sciences*, *7*(43), 4682–4685. https://doi.org/10.14260/jemds/2018/1044
Aliyah, S., & Nurajizah, N. (2025). Peningkatan kemampuan literasi numerasi anak usia 5-6 tahun menggunakan media loose part di Raudhatul Athfal Al Barokah Kecamatan Garut *Kota. Anaking: Jurnal Pendidikan Islam Anak U*sia Dini, 3(2), 48–57. https://doi.org/10.37968/anaking.v3i2.755
Amaliah, N., Asti, A. S. W., & Musi, M. A. (2023). Permainan balok angka terhadap kemampuan mengenal lambang bilangan anak usia 5–6 tahun di TKIT Wihdatul Ummah Kota Ma*kassar. Jurnal Keguruan Dan Ilmu* Pendidikan, 1(4), 297–303. https://doi.org/10.61116/jkip.v1i4.195
Anggraini, V. N., & Irsyad, M. (2021). Peningkatan penguasaan konsep lambang bilangan melalui metode bermain kartu angka pada anak usia dini pada siswa KB Bintang Kecil Desa Tegalsari Kecamatan K*radenan. Asghar: Journal of Children* Studies, 1(2), 135–143. https://doi.org/10.28918/asghar.v1i2.4739
Bachtiar, M. Y. (2021). Peningkatan kemampuan mengenal konsep bilangan melalui kegiatan bermain konstruktif untuk *siswa TK. Journal of Element*ary School, 4(2), 179–186. https://doi.org/10.31539/joes.v4i2.3127
Buldu, M., & Buldu, E. (2025). How to promote playful learning: Insights from innovative early childhood classrooms in the USA. Hum*anities and Social Sciences Communications*, 12*(1)*. https://doi.org/10.1057/s41599-025-05291-z
Chen, W. (2025). Problem-solving skills, memory power, and early childhood mathematics: Understanding the significance of the early childhood mathematics in an individual's life. *Journal of the Knowledge Economy*, *16*(1), 1–25. https://doi.org/10.1007/s13132-023-01557-6
Chopra, G. (2025). Developmentally appropriate activities for young children. In G. Chopra (Ed.), *Systems approach to early childhood development: Bridging theory, policy and practice* (pp. 97–147). Springer Nature Singapore. https://doi.org/10.1007/978-981-96-9377-1_5
Citra, N., Pradana, P. H., Nabilah, N., & N, A. I. (2022). Pengaruh permainan bowling bergambar angka terhadap keterampilan kognitif anak usi*a dini. Journal of Element*ary School, 5(2), 136–141. https://doi.org/10.31539/joes.v5i2.4103
Dierkx, V., van de Rijt, B., Hessen, D., van Luit, H., & van Viersen, S. (2025). Early numeracy development as a foundation of mathematics achievement in primary edu*cation. Learning and Individual Differ*ences, 121, 102706. https://doi.org/10.1016/j.lindif.2025.102706
Gnawali, Y. P. (2025). Role of manipulative materials in mathematics teaching and learning. *Education and Development*, *34*(1), 111–127. https://doi.org/10.3126/ed.v34i1.80293
Kemendikbud. (2021). Pand*uan penguatan literasi dan numerasi. Direktorat* Jenderal Pendidikan Anak Usia Dini, Pendidikan Dasar, dan Pendidikan Menengah Kementerian Pendidikan dan Kebudayaan https://doi.org/10.64628/aan.d95xe9umt
Kurniawan, F., Erita, Y., Syahrir, D., Qhairum, V., & Utami, N. (2022). The influence of students' environment on students' learning motivation. J*ournal of Digital Learning and Distance Education*, 1(8). https://doi.org/10.56778/jdlde.v1i7.58
Larbi, E., & Mavis, O. (2016). The use of manipulatives *in mathematics education. Journal of Education and Practice, 7(36). https://www.iiste.org/Journals/index.php/JEP/article/view/34636* https://doi.org/10.1007/978-3-319-32718-1_5e.org/Journals/index.php/JEP/article/view/34636 https://doi.org/10.1007/978-3-319-32718-1_5
Linder, S. M., & Simpson, A. (2018). Towards an understanding of early childhood mathematics education: A systematic review of the literature focusing on practicing and prospective teachers. Co*ntemporary Issues in Early Childhood*, 19*(3)*, 274–296. https://doi.org/10.1177/1463949117719553
Louw, J., & Claassens, H. (2024). Enhancing mathematical skills of learners in the early childhood phase through play-based learning: A review of literature. *Journal of Education and Learning*, *14*(2), 172. https://doi.org/10.5539/jel.v14n2p172
MacDonald, A. (2022). Contextual influences on children's mathematical understan*dings. Learning, Culture and Social* Interaction, 35, 100632. https://doi.org/10.1016/j.lcsi.2022.100632

Muliani, B. N. (2019). Peningkatan kemampuan kognitif dalam mengenal lambang bilangan melalui media model kereta api. *Pandawa: Jurnal Pendidikan* Dan Dakwah, 1(1), 20–39. https://doi.org/10.36088/pandawa.v1i1.314

Newman, S., & Latifi, A. (2021). Vygotsky, education, and teacher education. *Journal of Education for Teaching*, 47*(1)*, 4–17. https://doi.org/10.1080/02607476.2020.1831375

Nikiforidou, Z. (2019). Probabilities and preschoolers: Do tangible versus virtual manipulatives, sample space, and repetition matter? *Early Childhood Education Journal*, *47*(6), 769–777. https://doi.org/10.1007/s10643-019-00964-2

Nurhayati, L., Djoehaeni, H., Mariyana, R., & Rahaju, I. (2024). Pengaruh project based learning terhadap kemampuan literasi numerasi anak usia *dini. Aulad: Journal on Early* Childhood, 7(2), 616–625. https://doi.org/10.31004/aulad.v7i2.645

Oktaviana, H. D., Asriani, L., Dewi, Y. S., Fitriasari, A., & Watini, S. (2023). Implementasi model SIUUL dalam meningkatkan keterampilan MC pada AUD di PAUD Teratai. JIIP-Jurnal Ilmiah Ilmu Pendidi*kan, 6(6), 3724–3730 https://doi.org/10.54371/jiip.v6i6.2085*

Rahmawati, D. D., Saputri, A. D., Septiana, R., Utami, W. S., & Amanda, R. S. (2024). Pengimplementasian media circle maze untuk menstimulasi kemampuan problem solving anak usia dini. Journal of Education R*esearch, 5(2) https://doi.org/10.37985/jer.v5i2.1148*

Rambe, S. A., & Konadi, H. (2022). Kemampuan mengenal angka melalui media gambar asosia*tif. JUMPER: Journal of Educational Multidisciplinary* Research, 1(1), 41–46. https://doi.org/10.56921/jumper.v1i1.34

Rohmalina, R., Aprianti, E., & Lestari, R. H. (2020). Pendekatan open-ended dalam mempengaruhi kemampuan mengenal konsep bilangan anak usia *dini. Jurnal Obsesi: Jurnal Pendidikan Anak* Usia Dini, 5(2), 1409–1418. https://doi.org/10.31004/obsesi.v5i2.805

Romlah, M., Kurniah, N., & Wembrayarli. (2016). Peningkatan kemampuan berhitung anak melalui kegiatan bermain *sempoa. Jurnal Ilmiah* Potensia, 1(2), 72–77. https://doi.org/10.33369/jip.1.2.72-77

Sarama, J., & Clements, D. H. (2025). Playing to know the world mathematically. Ed*ucational Studies in Mathematics*. https://doi.org/10.1007/s10649-025-10446-5

Savitri, L. N. (2018). Pengaruh metode story telling melalui pemanfaatan program power point untuk meningkatkan kemampuan mengenal konsep bilangan 1-10 pada anak usia dini Manyaran *Semarang. Journal of Studies in Early Childhood Educa*tion (J-SECE), 1(1), 22–30. https://doi.org/10.31331/sece.v1i1.583

Setyaningtyas, P., & Harun, H. (2020). Brain based learning efektif meningkatkan kemampuan pemecahan masalah konsep bilangan anak usia *dini. Jurnal Obsesi: Jurnal Pendidikan Ana*k Usia Dini, 4(2), 1021–1028. https://doi.org/10.31004/obsesi.v4i2.479

Skalstad, I., Bjerknes, A. L., & Svendsen, S. (2025). Dinosaurs, mushrooms, and geometric forms: Conversations with young children about natural science and mathematics. E*arly Childhood Education Journal*. https://doi.org/10.1007/s10643-025-01850-w

Sugiono, S., & Kuntjojo, K. (2016). Pengembangan model permainan pra-calistung anak usia *dini. Jurnal Pendidikan* Usia Dini, 10(2), 255–276. https://doi.org/10.21009/JPUD.102.04

Sujatha, S., & Vinayakan, K. (2023). Practical approaches to teaching. Internat*ional Journal of Computational Research and Development (IJCRD) Impact, 8(2), 2456–3137* https://doi.org/10.4324/9781003344452

Sumawardani, A., Hafidah, R., & Nurjanah, N. E. (2019). Peningkatan kemampuan konsep bilangan melalui outdoor learning pada anak usia 4-*5 tahun. Kumar*a Cendekia, 7(4), 369–380. https://doi.org/10.20961/kc.v7i4.31776

Sun, J., Wang, Y., Li, J., Cheung, S. K., Zhou, Y., & Zhang, L. (2025). The need to go beyond "basic knowledge and basic skills": Development and validation of the early mathematical content inventory for preschool teachers. I*nternational Journal of Early Childhood*, *57*(3), 623–647. https://doi.org/10.1007/s13158-024-00413-1

Taylor, M. E., & Boyer, W. (2020). Play-based learning: Evidence-based research to improve children's learning experiences in the kindergarten cl*assroom. Childhood Educa*tion Journal, 48(2), 127–133. https://doi.org/10.1007/s10643-019-00989-7

Torres-Peña, R. C., Peña-González, D., & Ariza-Echeverri, E. A. (2025). Mathematical thinking in

preschool: Strengthening seriation and counting through problem solving. I*nternational Journal of Early Childhood*, *57*(2), 379–401. https://doi.org/10.1007/s13158-024-00402-4

Wu, M., & Lee, J. A. C. (2026). A comparative review of Montessori and Chinese preschools in early mathematics education in China. I*nternational Journal of Early Childhood.* https://doi.org/10.1007/s13158-026-00505-0

Wulan, G. A. N., Priatna, D., & Ismail, M. H. (2017). Meningkatkan kemampuan berhitung permulaan anak usia dini melalui media permainan stick *angka. Cakrawala Dini: Jurnal Pendidikan A*nak Usia Dini, 8(1). https://doi.org/10.17509/cd.v8i1