

PROFILING CHILDREN'S EARLY NUMERACY DEVELOPMENT THROUGH SINGING AS AN INTEGRATED PEDAGOGICAL APPROACH

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ABSTRACT

Early numeracy is fundamental to children's subsequent mathematical development; however, previous studies have predominantly emphasized instructional effectiveness through experimental designs while providing limited insight into how numeracy develops within authentic classroom practices. This study aimed to explore the profile of early numeracy skills among children aged 3–5 years, examine the implementation of the singing method, and analyze the factors influencing numeracy development at KB Miftahul Falah Pujer, Bondowoso. The study advances the conceptual understanding of singing by positioning it as an integrated pedagogical context rather than merely an instructional medium, revealing the progressive development of five interconnected numeracy competencies. This study employed a qualitative descriptive case study. The participants consisted of one principal, one classroom teacher, and children in Group A who were purposively selected because of their direct involvement in singing-based numeracy learning. Data were collected through non-participant classroom observations, semi-structured interviews, and document analysis, and analyzed using the interactive model of Miles, Huberman, and Saldaña. The trustworthiness of the findings was ensured through source and method triangulation, member checking, and prolonged engagement. The findings indicate that children's numeracy developed progressively from procedural counting to conceptual understanding through the integration of rhythm, movement, manipulatives, and dialogic interaction. Flexible pedagogical implementation and multimodal learning experiences strengthened conceptual numeracy, while developmental readiness, teacher competence, classroom participation, and parental support collectively shaped children's mathematical development. These findings highlight singing as a developmentally responsive pedagogical approach for promoting sustainable early numeracy learning.

Keywords: *Early Numeracy; Singing Method; Early Childhood Education; Music-Based Learning;*

ABSTRAK

Numerasi awal adalah aspek dasar bagi perkembangan matematika anak pada tahap selanjutnya. Namun, berbagai penelitian sebelumnya sebagian besar menekankan efektivitas instruksional melalui desain eksperimental sambil memberikan wawasan terbatas tentang bagaimana numerasi berkembang dalam praktik kelas yang otentik. Penelitian ini bertujuan untuk mengeksplorasi profil keterampilan numerasi awal pada anak-anak usia 3–5 tahun, meneliti penerapan metode bernyanyi, dan menganalisis faktor-faktor yang mempengaruhi perkembangan numerasi di KB Miftahul Falah Pujer, Bondowoso. Studi ini

meningkatkan pemahaman konseptual tentang bernyanyi dengan memposisikannya sebagai konteks pedagogis yang terintegrasi daripada sekadar media instruksional, mengungkapkan perkembangan progresif dari lima kompetensi numerasi yang saling terkait. Studi ini menggunakan studi kasus deskriptif kualitatif. Pesertanya terdiri dari satu kepala sekolah, satu guru kelas, dan anak-anak di Kelompok A yang dipilih secara purposif karena keterlibatan langsung mereka dalam pembelajaran numerasi berbasis nyanyian. Data dikumpulkan melalui observasi kelas non-partisipan, wawancara semi-terstruktur, dan analisis dokumen, serta dianalisis menggunakan model interaktif dari Miles, Huberman, dan Saldaña. Keandalan temuan dijamin melalui triangulasi sumber dan metode, pemeriksaan anggota, dan keterlibatan yang berkepanjangan. Temuan menunjukkan bahwa numerasi anak-anak berkembang secara progresif dari penghitungan prosedural ke pemahaman konseptual melalui integrasi ritme, gerakan, manipulatif, dan interaksi dialogis. Implementasi pedagogis yang fleksibel dan pengalaman belajar multimodal memperkuat numerasi konseptual, sementara kesiapan perkembangan, kompetensi guru, partisipasi kelas, dan dukungan orang tua secara kolektif membentuk perkembangan matematika anak-anak. Temuan ini menyoroti bernyanyi sebagai pendekatan pedagogis yang responsif terhadap perkembangan untuk mempromosikan pembelajaran numerasi awal yang berkelanjutan.

Kata Kunci: *Numerasi Awal; Metode Bernyanyi; Pendidikan Anak Usia Dini; Pembelajaran Berbasis Musik;*

A. Introduction

The development of numeracy skills in early childhood is a process of forming ways of thinking that occurs thru the interaction of learning experiences, environment, and developmental maturity, not merely the result of mechanical academic training (Afwā, 2026; Pradana, 2025; Rahim, 2023). According to the learning trajectories approach, each child builds mathematical understanding thru continuous developmental stages, so learning experiences must be tailored to the child's level of thinking (Iskandar et al., 2024). At the age range of 3–5 years,

children begin to develop the ability to recognize number symbols, understand quantity relationships, identify patterns, and use simple numeric concepts in daily activities (Risfaisal, 2025; Sufa, 2022). Therefore, early counting learning is not directed toward accelerating the mastery of arithmetic operations, but rather toward the formation of conceptual understanding thru concrete, contextual, and enjoyable experiences so that the foundation of numeracy can develop optimally (Anggraeni & Saputro, 2025).

Early counting skills are an important predictor of success in

learning mathematics at the next educational level because they are closely related to the development of reasoning, mathematical language, executive functions, and problem-solving abilities (Maesaroh et al., 2019). Research on longitudinal aspects shows that children with good early numeracy skills tend to demonstrate higher academic performance when entering elementary school compared to children who receive limited numeracy stimulation (Putri et al., 2024). Beside being influenced by individual readiness, the development of numeracy is also determined by the quality of learning experiences that children receive at home and in educational institutions (Rahmawati et al., 2026). The condition emphasizes that numeracy learning in early childhood education needs to be designed as a meaningful learning experience so that children can gradually build an understanding of number concepts, rather than just memorizing the sequence of numbers verbally (Rulianto et al., 2025).

Although various studies have emphasized the importance of early numeracy, learning practices in many early childhood education institutions

are still dominated by the introduction of numbers thru memorization, worksheet assignments, and teacher-centered exercises, thereby limiting children's opportunities to build conceptual understanding (Fatmawati et al., 2025). That approach is less aligned with the learning characteristics of early childhood children, who are more responsive to activities such as playing, moving, communicating, and exploring (Tukly et al., 2025). One relevant approach is the singing method because it can integrate elements of rhythm, language, repetition, movement, and social interaction into a complete learning experience. Musical activities not only help children remember the order of numbers but also strengthen the formation of meaning regarding numerical concepts thru multisensory experiences that are appropriate for their developmental stages (Rahayu et al., 2025). On that basis, the singing method can be regarded as a pedagogical approach that can facilitate the emergence of early counting skills more naturally during the learning process (Gillanders & Casal De La Fuente, 2020).

The numeracy skills of early childhood children are still a concern

in various countries because most children enter primary education with varying levels of mathematical readiness. In Indonesia, strengthening foundational skills, including numeracy, is also one of the focuses of early childhood education transformation because there are still learning practices that emphasize mastery of learning outcomes rather than the process of concept exploration (Banna et al., 2025). These conditions indicate that the main challenge of early counting learning does not solely lie in the child's low ability, but also in how teachers provide learning experiences that align with the child's developmental characteristics. Therefore, a learning approach that can integrate cognitive, affective, and psychomotor aspects in a balanced manner is needed so that numeracy skills develop thru meaningful learning experiences (Hui & Mahmud, 2023).

Various studies show that music-based activities contribute positively to the development of children's cognitive functions, particularly in aspects of attention, working memory, language skills, and pattern processing, which are prerequisites for developing numeracy skills

(Odhiambo, 2021). Music helps children recognize patterns thru rhythm, tempo, repetition, and sequence, making the process of understanding numerical concepts more natural (Azaryahu & Adi-Japha, 2022). In early childhood education, the singing method also enhances learning engagement because children gain enjoyable, interactive learning experiences that align with their tendency to learn thru play (Almigo & Sonda, 2025; Parker et al., 2022). Thus, songs not only serve as a medium of entertainment but also become a pedagogical tool that facilitates the formation of numerical concepts thru multisensory activities involving language, movement, hearing, and social interaction simultaneously (Di Paolo & Todino, 2025).

Although the effectiveness of the singing method in improving counting skills has been widely reported, most previous studies are still oriented toward measuring learning outcome improvements thru experimental approaches or classroom action research (Rachmawati, 2022; Su Sinn & Ku Wing, 2026). That approach yields information about changes in children's ability scores after

treatment, but it does not provide an overview of how early counting skills develop during the learning process. However, each child shows different characteristics of numeracy development as a consequence of variations in learning experiences, individual readiness, the quality of interactions with teachers, and the learning environment they receive (Rahmawati et al., 2026). Therefore, studies that capture the profile of early counting abilities in the context of natural learning become important to provide a more comprehensive understanding of the dynamics of early childhood numeracy development, while also serving as a basis for teachers to design learning strategies that are more responsive to the developmental needs of each child (Rahim, 2025).

Other studies have focused more on testing the effectiveness of teaching methods on improving early childhood counting skills. Experimental research and classroom action research generally conclude that the singing method has a positive effect on improving the ability to recognize numbers, count, and calculate simple objects. Nevertheless, the orientation of the

research is still dominated by measuring learning outcomes before and after the treatment, so that counting ability is positioned as a learning output, rather than as a developmental process that emerges gradually thru the child's interaction with their learning environment.

The focus of the research is not directed at the magnitude of the change in ability after the treatment, but on how the initial counting ability profile of children aged 3–5 years is formed, how variations in the implementation of the singing method support the emergence of that ability, and the factors that influence it during the learning process at KB Miftahul Falah Pujer Bondowoso. With this perspective, this research is expected to expand the understanding of early numeracy development in early childhood education while also providing an empirical foundation for teachers in designing learning that is more adaptive to the developmental characteristics of each child.

Starting from that condition, this research takes a different perspective by viewing the singing method not merely as a learning medium, but as a pedagogical context that allows various indicators of early counting

ability to emerge naturally. This research aims to describe the profile of early counting abilities of children aged 3–5 years during learning through the singing method, identify variations in the implementation of this method in learning practices, and analyze the factors influencing the development of children's numeracy skills at KB Miftahul Falah Pujer Bondowoso. This approach is expected to broaden the perspective on early numeracy assessment in early childhood education by emphasizing the developmental process rather than solely focusing on learning outcomes.

B. Methods

This study adopted a qualitative descriptive case study to explore the profile of early numeracy skills among children aged 3–5 years through the implementation of the singing method at KB Miftahul Falah Pujer, Bondowoso. This approach was selected because the study sought to understand children's naturally occurring numeracy development within an authentic classroom context rather than to evaluate the effectiveness of an instructional intervention. The participants consisted of the principal, one

classroom teacher, and children in Group A, who were purposively selected based on their direct involvement in singing-based numeracy learning. Their participation enabled the researcher to capture both pedagogical practices and children's responses during the learning process, providing a comprehensive understanding of early numeracy development within the research setting (Papandreou & Tsiouli, 2022).

Data were collected through non-participant classroom observations, semi-structured interviews, and document analysis. Observations focused on children's emerging numeracy abilities, including number recognition, counting, quantity comparison, and pattern identification during singing activities, while interviews explored teachers' instructional planning, classroom implementation, evaluation practices, and factors influencing children's numeracy development. Supporting documents, such as lesson plans, children's developmental records, and classroom documentation, were used to enrich and verify the findings. The data were analyzed using the interactive model of Miles, Huberman,

and Saldaña, involving data condensation, data display, and conclusion drawing conducted iteratively throughout the research process (Miles et al., 2014; Miles, 2020). To enhance the trustworthiness of the findings, the study employed source and method triangulation, member checking, and prolonged engagement to ensure that the interpretations accurately represented participants' experiences and the natural classroom context (Alenezi, 2023; Kartal, 2024)

C. Result and Discussion

1. Profile of Early Numeracy Skills of Children Aged 3–5 Years Through the Singing Method

The findings indicate that the profile of early numeracy skills among children aged 3–5 years was characterized by a gradual progression from procedural counting toward conceptual numerical understanding through sustained participation in singing-based learning activities. Rather than developing isolated mathematical competencies, children demonstrated an interconnected pattern of numerical development encompassing sequential counting, number

recognition, one-to-one correspondence, quantity comparison, and simple arithmetic reasoning. These competencies emerged through repeated engagement with songs that integrated rhythm, movement, concrete materials, and teacher–child interaction, suggesting that numeracy development was shaped not merely by children's cognitive maturation but also by the quality of pedagogical experiences provided during classroom learning. To provide a clearer overview of the developmental characteristics identified during classroom observations, interviews, and document analysis, the main indicators of children's early numeracy skills are summarized in Table 1. The table presents the dominant numeracy competencies observed, the supporting empirical evidence, and the corresponding pedagogical interpretation derived from the qualitative data.

Table 1. Summary of Findings on the Profile of Early Numeracy Skills Through the Singing Method

Main Theme	Empirical Findings	Supporting Evidence	Interpretation
Sequential counting	Children aged 3 years	Teacher interview;	Singing facilitated procedural

	were able to recite numbers 1–10 through repetitive songs.	classroom observation	al counting through rhythm and repetition.
Number recognition	Children gradually associated spoken numbers with numerical symbols.	Observation using number cards	Numerical symbols became meaningful through repeated multimodal exposure.
One-to-one correspondence	Children matched objects with spoken numbers while singing.	Manipulative activities	Concrete experiences strengthened numerical representation.
Quantity comparison	Children identified "more", "less", and "remaining" quantities during song activities.	Finger movement and toy manipulation	Numerical concepts developed beyond memorization.
Simple arithmetic reasoning	Older children demonstrated basic addition and subtraction through song scenarios.	"Five Little Ducks" activity	Singing promoted conceptual understanding of numerical relationships.

The interview data revealed that singing was deliberately positioned as the primary medium for introducing numerical concepts because it corresponded closely with children's developmental characteristics.

According to the classroom teacher, conventional number instruction often reduced children's engagement, whereas songs transformed mathematical learning into an enjoyable experience that encouraged spontaneous participation and reduced learning anxiety.

"Children between three and five years old naturally learn through play and enjoyable activities. When they are introduced to numbers through conventional instruction, they quickly lose interest. However, songs allow them to learn without feeling that they are studying mathematics because rhythm and melody make numerical concepts easier to absorb."
 (Classroom Teacher)

This explanation was consistently corroborated by classroom observations. During daily learning sessions, children participated enthusiastically in counting songs, accompanied by rhythmic clapping, body movements, and playful interaction with peers. Unlike teacher-centred counting activities, singing created a highly interactive learning atmosphere in which children voluntarily repeated numerical expressions, corrected one another's responses, and remained

engaged throughout the lesson. Observation records further indicated that children who were typically passive during conventional classroom activities became increasingly responsive once numerical learning was embedded within familiar songs. These behavioural patterns suggest that emotional engagement played a crucial role in facilitating children's willingness to participate in mathematical learning, thereby creating favourable conditions for the emergence of early numeracy skills.

The progression of children's numeracy development became evident in the gradual transition from memorizing numerical sequences to understanding numerical meaning. Younger children initially demonstrated rote counting, accurately reciting numbers from one to ten while singing but experiencing difficulty identifying numerical symbols or corresponding quantities outside the musical context. As participation in singing activities became more frequent, however, numerical sequences gradually evolved from verbal routines into meaningful cognitive representations. Older children increasingly demonstrated

the ability to associate spoken numbers with concrete objects, recognize numerical symbols, and explain simple quantitative relationships presented within song lyrics.

The classroom teacher described this developmental process as follows:

"Children around the age of three initially imitate the teacher while singing. Over time, repeated exposure to rhythm and melody helps them internalize the sequence of numbers. By the age of four to five, they begin to understand that each number represents a particular quantity rather than simply being part of the song."
(Classroom Teacher)

Observational evidence provided further support for this progression. During counting activities, younger children tended to rely heavily on rhythmic repetition, whereas older children increasingly manipulated concrete materials independently while responding to numerical instructions embedded within songs. Several children spontaneously grouped objects, identified the remaining quantity after one object had been removed, and corrected peers who miscounted during collaborative activities. More importantly, these mathematical responses frequently occurred without

direct teacher prompting, indicating that children were beginning to construct internal representations of numerical relationships instead of merely reproducing memorized verbal sequences.

From an analytical perspective, these findings suggest that singing functioned as a developmental scaffold rather than simply as a mnemonic device (Alisoy, 2025). At the initial stage of learning, rhythm and repetition reduced children's cognitive demands by organizing numerical information into predictable linguistic patterns. This process enabled children to establish procedural familiarity with numerical sequences before engaging in more cognitively demanding tasks requiring conceptual reasoning. As songs became increasingly integrated with gestures, concrete objects, and teacher questioning, children's procedural knowledge gradually transformed into conceptual understanding because numerical language was continuously connected with observable quantities and meaningful physical experiences. In other words, the pedagogical value of singing did not lie solely in facilitating memorization but in creating repeated opportunities for

children to negotiate mathematical meaning through multiple forms of sensory engagement.

This developmental mechanism explains why children's mathematical competencies evolved progressively instead of appearing simultaneously. Early numeracy involves far more than the ability to recite numbers correctly; it requires children to coordinate linguistic knowledge, perceptual experience, motor activity, memory, and logical reasoning into coherent mathematical understanding (Elia et al., 2023; Waite-Stupiansky, 2022). The integration of songs with movement and object manipulation enabled children to experience these dimensions simultaneously, thereby reducing the abstract nature of mathematical concepts. Consequently, numerical understanding emerged as a product of continuous interaction between cognitive readiness and pedagogical mediation rather than as a direct consequence of chronological age alone.

The findings substantially reinforce the Learning Trajectories framework proposed by Clements and Sarama (2025), which conceptualizes mathematical learning as a

progressive developmental pathway in which each competency establishes the foundation for subsequent conceptual growth (Clements & Sarama, 2025). Nevertheless, the present findings extend this perspective by demonstrating that developmental progression is strongly influenced by the quality of classroom mediation. While Learning Trajectories explains what developmental sequence children typically experience, the present study illustrates how singing-based pedagogy facilitates children's movement across those developmental stages. Repeated musical interaction functioned as an instructional catalyst that accelerated children's transition from procedural counting toward conceptual reasoning by embedding numerical concepts within enjoyable, socially meaningful classroom experiences.

Likewise, these findings provide additional empirical support for the sociocultural perspective of early mathematical development, which argues that children's cognitive growth is fundamentally mediated through interaction with more knowledgeable individuals and culturally meaningful learning activities. Throughout the

observed lessons, numerical concepts were not transmitted directly through explanation but were co-constructed through dialogue, imitation, collaborative singing, questioning, and shared manipulation of learning materials. Such interactions transformed mathematical learning into a socially negotiated activity in which conceptual understanding emerged through participation rather than passive reception. This finding suggests that children's mathematical competence is inseparable from the quality of pedagogical interaction established within the learning environment.

The present findings also both confirm and extend recent international evidence regarding music-based early mathematics instruction. Nitin et al. (2023) demonstrated that rhythmic musical experiences strengthen children's sequential processing and working memory (Nitin et al., 2023) while Kim et al. (2025) emphasized the importance of connecting mathematical language with meaningful classroom interaction (Kim et al., 2025). Similarly, Purpura et al. (2024) reported that conceptual numeracy develops more effectively

when numerical language is consistently integrated with concrete manipulation than when delivered through symbolic instruction alone (Purpura et al., 2024). However, these previous investigations predominantly evaluated instructional effectiveness using quantitative outcome measures. In contrast, the present study contributes a more comprehensive explanation of the pedagogical processes underlying children's mathematical development by illustrating how rhythm, movement, concrete representation, teacher interaction, and emotional engagement continuously interacted to shape children's developmental trajectories. Accordingly, the study contributes not only empirical confirmation of previous findings but also a deeper conceptual understanding of why singing promotes early numeracy development within authentic early childhood classrooms.

From a theoretical perspective, the findings suggest that early numeracy should be understood as a multidimensional developmental process emerging from the interaction between cognitive, linguistic, motor, emotional, and social experiences.

Singing therefore functions not merely as an instructional strategy but as a holistic pedagogical context through which these developmental dimensions become integrated into meaningful mathematical learning (Souto, 2024). Practically, the findings imply that early childhood teachers should move beyond using counting songs solely to support memorization. Instead, songs should be intentionally designed to incorporate questioning strategies, concrete learning materials, purposeful movement, and opportunities for children to explain their mathematical thinking. Such pedagogical integration enables children to construct conceptual mathematical understanding progressively while maintaining high levels of engagement, enjoyment, and confidence, thereby establishing stronger foundations for subsequent formal mathematics learning.

2. Implementation of the Singing Method in Facilitating Early Numeracy Development

The findings revealed that the implementation of the singing method was characterized by a flexible and developmentally responsive instructional approach in which songs were systematically integrated with

concrete learning materials, body movement, interactive questioning, and play-based classroom activities. Rather than functioning merely as an introductory or recreational activity, singing became the primary pedagogical medium through which early numeracy concepts were introduced, explored, and reinforced throughout the learning process. The teacher continuously adapted songs, classroom interaction, and learning media according to children's responses and developmental readiness, enabling mathematical concepts to be experienced through meaningful and enjoyable learning situations. The qualitative findings further indicate that the implementation of the singing method consisted of several interconnected instructional components. These components are summarized in Table 2 to illustrate how each pedagogical strategy contributed to children's early numeracy development.

Table 2. Summary of the
Implementation of the Singing
Method

Learning Component	Classroom Practice	Children's Response	Contribution to Numeracy
Songs	Counting songs	High engagement	Reinforced number sequence

	integrated into daily lessons		
Body movement	Clapping, jumping, finger counting	Active participation	Strengthened one-to-one correspondence
Concrete materials	Stones, sticks, toys, number cards	Better object-number association	Improved quantity recognition
Interactive questioning	Teacher paused songs and asked numerical questions	Children explained answers	Developed conceptual reasoning
Musical variation	Local songs, modified lyrics, percussion	Sustained motivation	Prevented boredom and maintained participation

The classroom teacher explained that instructional variation was intentionally designed to maintain children's engagement while simultaneously strengthening their understanding of mathematical concepts.

“Using the same songs repeatedly makes children lose interest. Therefore, I modify the songs, movements, and learning materials according to the classroom situation so that children remain engaged while learning the same mathematical concepts.” (Classroom Teacher)

This explanation was supported by classroom observations showing that numeracy learning consistently combined songs with finger movements, body gestures, concrete manipulatives, and teacher questioning. Children remained actively involved throughout the activities, interacted with peers, and demonstrated greater willingness to participate when mathematical tasks were embedded within playful musical experiences. Lesson documentation further confirmed that these instructional variations were systematically incorporated into daily lesson planning rather than implemented incidentally.

These findings indicate that the effectiveness of the singing method cannot be attributed solely to musical repetition. Instead, its pedagogical value lies in the teacher's ability to orchestrate multiple instructional elements into a coherent learning experience. Songs provided an engaging instructional framework, yet conceptual mathematical learning emerged because rhythm was continuously connected with movement, concrete representation, dialogue, and guided interaction. Consequently, singing functioned as

an integrated pedagogical approach in which auditory, visual, kinesthetic, and social experiences complemented one another in supporting children's mathematical development.

From an analytical perspective, the implementation observed in this study reflects a shift from viewing singing as an instructional medium toward understanding it as a pedagogical process. Many early childhood classrooms continue to employ songs primarily to attract children's attention or to create an enjoyable classroom atmosphere. In contrast, the present findings demonstrate that songs became pedagogically meaningful because every musical activity was intentionally linked to specific mathematical objectives. Teachers did not merely ask children to sing counting songs; they simultaneously encouraged children to manipulate concrete objects, predict numerical changes, explain their reasoning, and respond to reflective questions. Such pedagogical integration transformed musical activities into opportunities for constructing mathematical understanding rather than simply rehearsing numerical vocabulary.

The findings further suggest that instructional flexibility played a central role in sustaining children's cognitive engagement (Thomas et al., 2020). Young children possess relatively short attention spans and demonstrate considerable variation in learning preferences. Consequently, repeatedly presenting identical musical activities is unlikely to maintain meaningful engagement throughout the learning process. By continuously modifying songs, incorporating movement, introducing different manipulatives, and varying classroom interaction, the teacher created diverse learning experiences that accommodated children's developmental needs while preserving the continuity of mathematical learning. This flexibility enabled children to revisit identical mathematical concepts through multiple representational forms, thereby strengthening conceptual understanding rather than encouraging mechanical repetition.

The observed implementation also illustrates the importance of multimodal learning in early childhood mathematics education. Rather than processing numerical information exclusively through verbal instruction,

children simultaneously listened to songs, performed coordinated body movements, manipulated concrete materials, communicated with peers, and responded to teacher questions. These overlapping learning experiences reduced the abstract nature of mathematical concepts by providing multiple pathways through which numerical meaning could be constructed. Accordingly, children's mathematical understanding emerged through the integration of sensory, linguistic, motor, and social experiences instead of depending upon a single instructional modality (Videla & Abrahamson, 2026).

These findings are consistent with contemporary perspectives on early mathematics learning that emphasize the importance of meaningful, interactive, and child-centred pedagogical experiences. Purpura et al. (2024) argue that early numeracy develops more effectively when mathematical language is embedded within authentic classroom interaction rather than presented through isolated symbolic instruction (Purpura et al., 2024). Similarly, Nitin et al. (2023) demonstrated that rhythm and musical

engagement enhance children's attention and sequential processing, thereby creating favourable conditions for mathematical learning (Nitin et al., 2023). The present findings, however, extend these studies by showing that music alone is insufficient to explain children's conceptual development. Instead, the educational value of singing emerged through its deliberate integration with manipulatives, movement, dialogue, and continuous pedagogical adaptation. This integrated perspective remains relatively underexplored within previous studies, which have predominantly examined the effectiveness of music-based interventions through experimental comparisons rather than through detailed analysis of classroom implementation.

The findings also resonate with sociocultural perspectives that conceptualize learning as a process mediated through interaction, participation, and culturally meaningful activities (Mukhasibi & Wahyudi, 2026). Throughout the observed lessons, mathematical knowledge was co-constructed through collaborative singing, teacher scaffolding, peer interaction, and shared manipulation

of learning materials. These interactions positioned children as active participants who negotiated mathematical meaning rather than passively receiving numerical information. Consequently, the implementation of the singing method should be understood not simply as the application of an instructional strategy but as the creation of a learning ecology in which cognitive development is continuously supported through meaningful social participation.

From a theoretical perspective, this study broadens current understanding of music-based numeracy instruction by demonstrating that the effectiveness of singing depends upon the quality of pedagogical design rather than the presence of music itself. Singing became educationally meaningful because it was intentionally integrated with instructional components that supported children's conceptual development. Practically, the findings suggest that early childhood teachers should design singing activities as structured mathematical learning experiences by combining musical repetition with manipulatives, purposeful movement, reflective

questioning, and collaborative interaction. Such pedagogical integration enables children to construct mathematical understanding more deeply while maintaining high levels of motivation, participation, and enjoyment, thereby contributing to more developmentally appropriate and sustainable early numeracy learning.

3. Factors Influencing the Development of Early Numeracy Skills Through the Singing Method

Children's early numeracy development through the singing method was shaped by the dynamic interaction of multiple factors, including developmental readiness, teachers' pedagogical competence, active classroom participation, concrete learning experiences, and parental support. Rather than operating independently, these factors complemented one another in creating learning conditions that enabled children to construct mathematical understanding progressively. The analysis also identified several interrelated factors that influenced children's numeracy development throughout the implementation of the singing method. As summarized in

Table 3, these factors emerged consistently across observations, interviews, and supporting documents.

Table 3. Factors Influencing Early Numeracy Development

Factor	Empirical Evidence	Influence on Learning
Developmental readiness	Differences between children aged 3 and 5 years	Determined pace of conceptual understanding
Teacher pedagogical competence	Adaptation of songs, media, and questioning	Enhanced conceptual learning
Classroom participation	Active singing and interaction	Increased mathematical engagement
Concrete learning experiences	Manipulatives and movement	Facilitated conceptual understanding
Parental support	Repetition of songs at home	Strengthened retention and reinforcement

As the classroom teacher explained, *“Every child develops differently. Some understand numbers quickly, while others require more repetition, and this is strongly influenced by their confidence and support from home.”* (Classroom Teacher).

This explanation was corroborated by classroom observations showing that children who actively participated in singing activities, manipulated concrete materials, and interacted confidently

with teachers and peers demonstrated more consistent progress in recognizing quantities and solving simple numerical tasks than those who participated less actively.

These findings suggest that the effectiveness of the singing method depended less on the instructional strategy itself than on the interaction between children's individual characteristics and the quality of pedagogical support provided during learning (D & Kumar, 2020). Although all children experienced identical classroom activities, their mathematical development followed different trajectories because each child entered the learning process with varying levels of cognitive readiness, confidence, prior experiences, and opportunities to reinforce numeracy beyond the classroom. Consequently, children's mathematical progress should be understood as a developmental process emerging from continuous interaction between learner characteristics and responsive instructional practices rather than as a direct consequence of exposure to a particular teaching method.

An important mechanism underlying this developmental process was the teacher's pedagogical

competence in adapting learning experiences to children's diverse needs. Songs alone did not produce conceptual understanding; rather, they became educationally meaningful because the teacher consistently integrated rhythm with body movement, manipulatives, questioning strategies, and collaborative interaction. Such pedagogical flexibility allowed children to revisit identical mathematical concepts through multiple representational forms, thereby reducing the abstract nature of numbers and facilitating conceptual understanding. Equally important, children's willingness to participate actively created opportunities for continuous dialogue, exploration, and feedback, enabling mathematical ideas to be constructed through meaningful social interaction rather than passive reception.

This interpretation supports the Learning Trajectories framework, which conceptualizes early mathematical development as a progressive sequence of interconnected competencies (Clements & Sarama, 2025). However, the present findings further indicate that children's

progression across these developmental pathways is strongly mediated by pedagogical quality and learning context. The findings also resonate with sociocultural perspectives that emphasize knowledge construction through guided participation and interaction with more knowledgeable others (Mukhasibi & Wahyudi, 2026). In this study, mathematical understanding evolved because children repeatedly engaged in collaborative musical experiences that linked language, movement, concrete representation, and dialogue into a coherent learning process. Thus, developmental readiness alone was insufficient to explain children's progress; meaningful pedagogical mediation played an equally critical role.

The present findings are broadly consistent with previous international research demonstrating that The findings also resonate with sociocultural perspectives that conceptualize learning as a process mediated through interaction, participation, and culturally meaningful activities. The findings also resonate with sociocultural perspectives that conceptualize learning as a process

mediated through interaction, participation, and culturally meaningful activities. The findings also resonate with sociocultural perspectives that conceptualize learning as a process mediated through interaction, participation, and culturally meaningful activities (Purpura et al., 2024; Stahl & Hakkarainen, 2021). Likewise, studies by Nitin et al. (2021) have shown that musical engagement enhances children's attention and sequential processing, creating favourable conditions for mathematical learning (Nitin et al., 2023). Nevertheless, unlike earlier studies that predominantly examined isolated instructional interventions, the present study illustrates how developmental readiness, pedagogical adaptation, classroom participation, and family support continuously interacted within authentic classroom practice. This integrated perspective provides a more comprehensive explanation of why children exposed to the same instructional activities demonstrated different developmental trajectories.

From a theoretical perspective, the study reinforces the view that early numeracy should be understood as a multidimensional developmental process shaped by reciprocal

interactions between children and their learning environments rather than by instructional techniques alone. Practically, the findings highlight that effective numeracy instruction requires teachers to move beyond selecting appropriate learning methods toward creating adaptive pedagogical environments that accommodate children's developmental diversity, encourage active participation, and strengthen collaboration with families. Such an approach enables singing to function not merely as an engaging classroom activity but as a meaningful pedagogical context that supports sustainable conceptual development in early mathematics.

D. Conclusion

This study demonstrates that the singing method provides a developmentally appropriate pedagogical approach for fostering early numeracy skills among children aged 3–5 years. Children's numeracy developed progressively from procedural counting toward conceptual understanding, encompassing number recognition, one-to-one correspondence, quantity comparison, and simple arithmetic

reasoning. These competencies emerged through meaningful musical experiences that integrated rhythm, movement, concrete learning materials, and teacher–child interaction. The findings further reveal that the effectiveness of the singing method was determined not merely by musical repetition but by its pedagogical implementation, which continuously adapted learning experiences to children's developmental characteristics while encouraging active participation and mathematical meaning-making.

The findings contribute to the growing body of knowledge on early childhood mathematics education by positioning singing as an integrated pedagogical approach rather than merely an instructional medium. This study demonstrates that children's conceptual understanding of numbers develops through the interaction of cognitive, linguistic, motor, social, and emotional experiences embedded within authentic classroom activities. These findings also underscore the importance of teachers' pedagogical competence in designing developmentally responsive numeracy instruction that combines songs with manipulatives, purposeful

movement, dialogic interaction, and continuous instructional adaptation. Such an approach provides practical guidance for early childhood educators seeking to strengthen foundational numeracy through meaningful and engaging learning experiences.

This study was conducted in a single early childhood education setting, limiting the transferability of its findings to other institutional and socio-cultural contexts. In addition, the research focused primarily on classroom implementation and did not examine the long-term development of children's numeracy skills or the influence of family learning environments in greater depth. Future studies are therefore encouraged to involve multiple educational settings, adopt longitudinal or mixed-method research designs, and further investigate how parental engagement, teacher pedagogical practices, and diverse socio-cultural contexts influence the sustainability of early numeracy development through music-based learning. Such investigations would provide broader empirical evidence for designing more adaptive and context-sensitive

numeracy instruction in early childhood education.

REFERENCES

- Afwa, I. Z. (2026). Pembelajaran Matematika Berbasis Bermain pada PAUD: Kajian Filosofis dan Pedagogis. *Saimika: Jurnal Kajian Matematika Dan Sains*, 1(1), 12–26.
- Alenezi, A. (2023). TEACHER PERSPECTIVES ON AI-DRIVEN GAMIFICATION: IMPACT ON STUDENT MOTIVATION, ENGAGEMENT, AND LEARNING OUTCOMES. *Information Technologies and Learning Tools*, 97(5), 138–148.
<https://doi.org/10.33407/itlt.v97i5.5437>
- Alisoy, H. (2025). Integrating Music into Curriculum Design: Strategies for Enhancing Student Achievement and Cognitive Skills. *Acta Globalis Humanitatis et Linguarum*, 2(4), 37–70.
<https://doi.org/10.69760/aghel.0250040002>
- Almigo, N., & Sonda, R. A. (2025). Strategi Motivasi Pembelajaran Untuk Meningkatkan Minat Anak PAUD di Desa Tanjung Tambak. *Jurnal Pengabdian Inovasi Masyarakat Indonesia*, 4(1), 45–52.
<https://doi.org/10.29303/jpimi.v4i1.6132>
- Anggraeni, N., & Saputro, B. A. (2025). Strategi Efektif Mengenalkan Konsep Bilangan Pada Anak Usia Dini Melalui Bermain. *Potlot Publisher*.

- <https://terbitan.potlot.id/index.php/buku/article/view/106>
- Azaryahu, L., & Adi-Japha, E. (2022). "MusiMath"—A music-based intervention program for learning patterns and symmetry. *The Journal of Experimental Education*, 90(2), 319–343.
<https://doi.org/10.1080/00220973.2020.1799316>
- Banna, H. A., Kurniasih, Faisal, R., Musyadad, M. A., & Yudha, H. S. (2025). Inovasi Pembelajaran Anak Usia Dini Berbasis Teknologi Untuk Meningkatkan Keterampilan Literasi Dan Numerasi Anak: Penelitian. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*, 4(1), 1385–1393.
<https://doi.org/10.31004/jerkin.v4i1.1739>
- Clements, D. H., & Sarama, J. (2025). Systematic review of learning trajectories in early mathematics. *ZDM – Mathematics Education*, 57(4), 637–650.
<https://doi.org/10.1007/s11858-024-01644-1>
- D, S. P., & Kumar, R. (2020). *Concepts of Learner-Centred Teaching* (SSRN Scholarly Paper No. 4004513). Social Science Research Network.
<https://papers.ssrn.com/abstract=4004513>
- Di Paolo, A., & Todino, M. D. (2025). Inclusive Music Education in the Digital Age: The Role of Technology and Edugames in Supporting Students with Special Educational Needs. *Encyclopedia*, 5(3), 102.
<https://doi.org/10.3390/encyclopedia5030102>
- Elia, I., Baccaglini-Frank, A., Levenson, E., Matsuo, N., Feza, N., & Lisarelli, G. (2023). Early Childhood Mathematics Education Research: Overview of Latest Developments And Looking Ahead. *Annales de Didactique et de Sciences Cognitives. Revue Internationale de Didactique Des Mathématiques*, (28), (75–129).
<https://doi.org/10.4000/adsc.3113>
- Fatmawati, N., Nopiana, Sofia, A., Pradini, S., & Anggraini, G. F. (2025). Pelatihan Guru PAUD dalam Praktik Compassion pada Kegiatan Numerasi Anak Usia Dini. *Dedikasi: Jurnal Pengabdian Masyarakat*, 1(2), 70–82.
- Gillanders, C., & Casal De La Fuente, L. (2020). Enhancing mathematical thinking in early childhood through music. *Pedagogies: An International Journal*, 15(1), 60–79.
<https://doi.org/10.1080/1554480X.2019.1673167>
- Hui, H. B., & Mahmud, M. S. (2023). Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Frontiers in Psychology*, 14.
<https://doi.org/10.3389/fpsyg.2023.1105806>
- Iskandar, B., Hashipah, H., & Zulaeha, V. S. (2024). Integrasi Lingkungan dalam Pembelajaran Matematika: Studi Literatur Pembelajaran Kontekstual Berbasis Lingkungan bagi Anak Usia Dini. *JURNAL PAUD*

- AGAPEDIA, 8(2), 243–252.
<https://doi.org/10.17509/jpa.v8i2.78851>
- Kartal, G. (2024). The influence of ChatGPT on thinking skills and creativity of EFL student teachers: A narrative inquiry. *Journal of Education for Teaching*, 50(4), 627–642.
<https://doi.org/10.1080/02607476.2024.2326502>
- Kim, J., Hornburg, C. B., Grose, G. E., Levinson, T. G., & Fazio, L. K. (2025). Picturing mathematicians: Examining how gender and math anxiety relate to students' representations of mathematicians in late elementary and middle school. *Journal of Experimental Child Psychology*, 258, 106290.
<https://doi.org/10.1016/j.jecp.2025.106290>
- Maesaroh, M., Sumardi, S., & Nur, L. (2019). KEMAMPUAN BERHITUNG PERMULAAN ANAK TAMAN KANAK-KANAK KELOMPOK B SE-KELURAHAN LENGKONGSARI KOTA TASEMALAYA. *JURNAL PAUD AGAPEDIA*, 3(1), 61–75.
<https://doi.org/10.17509/jpa.v3i1.26669>
- Miles, M. B., author. (2020). *Qualitative data analysis: A methods sourcebook*. SAGE, [2020].
<https://search.library.wisc.edu/catalog/9912705832902121>
- Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis*. SAGE.
- Mukhasibi, A., & Wahyudi, I. (2026). Immersive Arabic Islamic Environment and Student Engagement: Evaluating the Linguistic Impact of World Arabic Language. *Farasyah: Journal of Linguistics and Language Education*, 1(1), 1–12.
- Nitin, R., Gustavson, D. E., Aaron, A. S., Boorum, O. A., Bush, C. T., Wiens, N., Vaughan, C., Persici, V., Blain, S. D., Soman, U., Hambrick, D. Z., Camarata, S. M., McAuley, J. D., & Gordon, R. L. (2023). Exploring individual differences in musical rhythm and grammar skills in school-aged children with typically developing language. *Scientific Reports*, 13(1), 2201.
<https://doi.org/10.1038/s41598-022-21902-0>
- Odhiambo, D. (2021). Use of songs in teaching and learning ionic bonds: A case of a secondary school in Vihiga County, Kenya. *Master of Education*.
https://ecommons.aku.edu/etd_tz_ied_m-ed/412
- Papandreou, M., & Tsiouli, M. (2022). Noticing and understanding children's everyday mathematics during play in early childhood classrooms. *International Journal of Early Years Education*, 30(4), 730–747.
<https://doi.org/10.1080/09669760.2020.1742673>
- Parker, R., Thomsen, B. S., & Berry, A. (2022). Learning Through Play at School – A Framework for Policy and Practice. *Frontiers in Education*, 7.

- <https://doi.org/10.3389/feduc.2022.751801>
- Pradana, L. N. (2025). *Membangun Kecakapan Numerasi Sejak Dini: Konsep, Praktik, dan Refleksi untuk Sekolah Dasar*. CV. AE MEDIA GRAFIKA. https://books.google.com/books?hl=en&lr=&id=1QI3EQAAQB&oi=fnd&pg=PA1&dq=Perkembangan+kemampuan+numerasi+pada+anak+usia+dini+menerupakan+proses+pembentukan+cara+berpikir+yang+berlangsung+melalui+interaksi+antara+pengalaman+belajar,+lingkungan,+dan+kematangan+perkembangan,+bukan+sekadar+hasil+dari+latihan+akademik+yang+bersifat+mekanis&ots=Fq_fdx9WkG&sig=0v95f_fokwitzuSyUpj0U2MZV6E
- Purpura, D. J., O'Rear, C. D., Ellis, A., Logan, J. A. R., Westerberg, L., Ehrman, P., King, Y. A., Vander Tuin, M., Nordgren, I., Anderson, K., Cosso, J., Zippert, E., Napoli, A. R., Hornburg, C. B., Schmitt, S. A., & Dobbs-Oates, J. (2024). Unique and combined effects of quantitative mathematical language and numeracy instruction within a picture book intervention: A registered report. *Journal of Educational Psychology*, 116(1), 1–19. <https://doi.org/10.1037/edu0000820>
- Putri, A. Y., Mariana, N., & Muhimmah, H. A. (2024). Eksplorasi Kemampuan Numerasi pada Anak Lamban Belajar di Kelas Awal: Studi Kasus di Sekolah Dasar. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, 4(4), 1555–1563.
- <https://doi.org/10.53299/jppi.v4i4.851>
- Rachmawati, R. E. (2022). *Upaya Meningkatkan Kemampuan Berhitung Menggunakan Media Kartu Angka Dan Metode Bernyanyi Pada Anak Usia Dini 5-6 Tahun Di Tk Aisyiyah Bustanul Athfal 43 Ciledug* [B.S. thesis]. Jakarta: FITK UIN Syarif Hidayatullah Jakarta.
- Rahayu, F. T. N., Gunara, S., Sella, F., & Jammeh, S. (2025). Singing as a Meaningful Learning Approach for Introducing Numbers and Letters in Early Childhood Education. *Musikolastika: Jurnal Pertunjukan Dan Pendidikan Musik*, 7(2). <https://doi.org/10.24036/musikolastika.v7i2.271>
- Rahim, A. (2023). Strategi Peningkatan Ketrampilan Literasi dan Numerasi Pada Anak Usia Dini. *Journal Sains and Education*, 1(3), 72–79. <https://doi.org/10.59561/jse.v1i3.232>
- Rahim, A. (2025). Pentingnya Mengembangkan Kemampuan Literasi Dan Numerasi Sejak Usia Dini di Daerah Makassar. *SABAJAYA Jurnal Pengabdian Kepada Masyarakat*, 3(04), 246–252.
- Rahmawati, A., Asih, E., Husniyah, N., A, S. R., & Bayuni, T. C. (2026). Analisis Pengaruh Lingkungan Belajar Terhadap Pengembangan Literasi Numerasi Siswa Sekolah Dasar. *Jurnal Inovasi Pendidikan Dan Pembelajaran*, 2(1), 15–19. <https://doi.org/10.63980/eduvasi.v2i1.140>

- Risfaisal, R. (2025). Peran Lembaga PAUD Pertiwi Bulukumba Dalam Mengembangkan Kemampuan Sosialisasi Anak di Keluarga (Suatu Tinjauan Sosiologi). *DISCOURSE: Indonesian Journal of Social Studies and Education*, 2(2), 81–91.
<https://doi.org/10.69875/djosse.v2i2.137>
- Rulianto, U. F. F. M., Hasanah, H., & Zahro, I. (2025). Pengaruh Media Papan Jari Pintar Terhadap Kemampuan Numerasi Dasar Anak Usia 5-6 Tahun di TK Anisa Kebonsari Jember. *Jurnal Kajian Ilmu Pendidikan (JKIP)*, 6(2), 652–664.
<https://doi.org/10.55583/jkip.v6i2.1449>
- Souto, O. (2024). *The interrelated learning of mathematics and music*.
<http://hdl.handle.net/10400.5/99768>
- Stahl, G., & Hakkarainen, K. (2021). Theories of CSCL. In U. Cress, C. Rosé, A. F. Wise, & J. Oshima (Eds.), *International Handbook of Computer-Supported Collaborative Learning* (pp. 23–43). Springer International Publishing.
https://doi.org/10.1007/978-3-030-65291-3_2
- Su Sinn, O., & Ku Wing, C. (2026). Twenty-first century learning skills and music engagement among young children: A systematic review. *Asia Pacific Journal of Education*, 46(3), 678–698.
<https://doi.org/10.1080/02188791.2024.2385835>
- Sufa, F. F. (2022). *Konsep Matematika untuk Anak Usia Dini*. Unisri Press.
- Thomas, J., Dymont, J., & Hay, I. (2020). 'It showed me that I was not dumb' the role of flexible learning programmes in enabling cognitive (re)-engagement. *International Journal of Inclusive Education*, 24(8), 809–827.
<https://doi.org/10.1080/13603116.2018.1492641>
- Tukly, W. V., Nilapancuran, M. M., Matital, K. A., Kothel, S., & Lesbassa, L. (2025). Membangun Fondasi Pendidikan Anak Usia Dini Melalui Pendekatan Pembelajaran yang Menyenangkan. *CARONG: Jurnal Pendidikan, Sosial Dan Humaniora*, 2(2), 754–764.
<https://doi.org/10.62710/vp1c3790>
- Videla, R., & Abrahamson, D. (2026). Inclusive design for expansive theory: What we learn as researchers and teachers when we develop educational resources for diverse students in mathematics. *Mathematics Education Research Journal*.
<https://doi.org/10.1007/s13394-026-00591-2>
- Waite-Stupiansky, S. (2022). Jean Piaget's Constructivist Theory of Learning. In *Theories of Early Childhood Education* (2nd ed.). Routledge.