

Proportional Calistung via Natural Loose Parts: A Cognitive Limit Analysis

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Abstract

Early reading, writing, and arithmetic (calistung) are still widely taught through abstract, worksheet-based drills that do not match young children's developmental characteristics. This study analyzes the epistemology of proportional calistung in relation to the cognitive limits of early childhood, using natural loose parts as concrete learning media. A qualitative-descriptive library research design was used. Data were drawn from the theories of Jean Piaget, Lev Vygotsky, and Jerome Bruner, together with 13 journal articles, one conference paper, and one book, mostly published between 2021 and 2026 and retrieved through Google Scholar. Data were analyzed using content analysis (data reduction, data display, and conclusion drawing). The analysis suggests that proportional calistung (1) respects children's developmental readiness at the preoperational stage, (2) follows a progression from enactive to iconic to symbolic representation, and (3) provides gradually withdrawn scaffolding within the zone of proximal development, for which natural loose parts can serve as a bridging medium. Natural loose parts are therefore conceptually consistent with early childhood cognitive development. As a literature review, this study offers a conceptual framework only, and empirical testing is still needed.

Keywords: Proportional, Literacy, Numeracy, Cognitive Limits, Loose Parts, Early Childhood

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1. INTRODUCTION

Early Childhood Education (ECE) is a form of preschool education that precedes primary education. Law No. 20 of 2003 on the National Education System defines early childhood education as an effort to provide guidance to children from birth to six years of age through educational stimulation aimed at supporting their physical and spiritual growth and development and preparing them for further education. The urgency of educating children from an early age is grounded in the understanding that childhood represents a golden age, a period in which children's functions and abilities develop rapidly. These emerging potentials require appropriate stimulation from the adults around them so that children's abilities can be actualized and developed optimally (Farikhah & Ariestina, 2020).

However, in practice, young children are often confronted with academic expectations that are not aligned with their developmental stages. Many educational institutions and parents continue to perceive reading, writing, and arithmetic (calistung) skills as primary indicators of intelligence, thereby encouraging children to engage in academic learning at an excessively early age. This condition indicates a gap between societal understanding of children's learning readiness and the fundamental principles of early childhood education, which should emphasize play, exploration, and meaningful experiences. Consequently, the principle of "learning through play" is increasingly replaced by abstract academic learning (Nadhifah & Aisyah, 2025). Everything in a person's environment holds potential value if they engage their cognitive reasoning to contemplate it. (Whildan, 2021) Therefore, once a child begins to apply conceptual thinking, it becomes the responsibility of education to foster it. The cognitive domain plays a central role, as success in developing cognitive capabilities lays the foundation for success across other developmental areas.

Previous studies have examined loose parts media for early literacy and numeracy. Reghita and Hariyanti (2023) explored its use for numeracy literacy, and Weni et al. (2026) developed a loose-parts-

based integrative literacy model (LILP) to improve the reading skills of children aged 5–6 at TK Harapan Umat. However, these studies focus on the practical use of the media and do not examine the epistemological and developmental basis for introducing calistung proportionally. This leaves a conceptual gap: an integrative framework linking Piaget, Vygotsky, and Bruner to proportional calistung through natural loose parts.

From an epistemological perspective, epistemology seeks to examine how something comes into existence, how it can be known, how it can be distinguished from other forms of knowledge, and how its conditions and characteristics are understood within particular contexts of space and time (Pajriani dkk., 2023). This perspective raises a fundamental question: When and how should reading, writing, and arithmetic (calistung) be introduced to young children? As a branch of the philosophy of science, epistemology examines the sources, boundaries, and processes through which knowledge is acquired. When abstract knowledge in the form of letters and numerical symbols is imposed before children are cognitively ready, it may exceed the appropriate boundaries of knowledge acquisition for their developmental stage.

Several philosophical perspectives on child development provide a theoretical foundation for this issue. Jean Piaget proposed that children aged two to seven years are in the preoperational stage, during which their thinking remains limited in its ability to perform abstract logical operations and is strongly supported by concrete experiences and representations. Similarly, Jerome Bruner's theory of representation emphasizes three sequential modes of learning: enactive, iconic, and symbolic. Lev Vygotsky adds a social dimension: children's learning is shaped by guided interaction within the zone of proximal development, supported by scaffolding that is gradually withdrawn as independence grows (Wardani et al., 2023). Moving directly to the symbolic stage without sufficient concrete and representational experiences may disrupt the developmental pathway through which children construct knowledge.

At this point, learning media play a crucial role. Loose parts, particularly natural materials such as stones, seeds, leaves, and twigs, can function as concrete learning resources that bridge children's direct experiences and their understanding of abstract symbols. Through loose parts, children can manipulate, arrange, compare, count, and explore concepts related to reading, writing, and arithmetic through firsthand experiences. Consequently, calistung instruction can be delivered proportionally, in accordance with children's developmental stages and cognitive readiness, without exceeding the cognitive boundaries appropriate to their age.

Based on this rationale, this study is important because it analyzes the epistemology of proportional calistung in relation to the cognitive boundaries of early childhood through concrete learning based on natural loose parts. The study seeks to contribute a conceptual framework for understanding how calistung can be introduced in ways that respect children's developmental readiness while maintaining a meaningful progression from concrete experiences toward abstract understanding.

2. METHOD

This study employed a qualitative-descriptive library research design to examine the conceptual foundations of proportional reading, writing, and arithmetic (calistung) instruction in early childhood education through the use of natural loose parts. This approach was selected because the study aimed to synthesize existing theoretical perspectives and research findings rather than measure the effectiveness of a particular instructional intervention. The analysis focused on the relationship between children's cognitive development, the gradual introduction of literacy and numeracy concepts, and the use of concrete learning materials to support meaningful learning experiences.

The literature consisted of three foundational theoretical works by Piaget (1952), Vygotsky (1978), and Bruner (1966), supported by secondary sources addressing early childhood cognitive development, calistung instruction, and loose-parts-based learning. The secondary literature comprised 13 journal articles, one conference paper, one book, and one unpublished manuscript. Most secondary sources

were published between 2021 and 2026. An earlier study by Farikhah and Ariestina (2020) was retained because of its relevance to the discussion of calistung practices in early childhood education. Law No. 20 of 2003 concerning the National Education System was also consulted as a legal reference. Relevant literature was identified through Google Scholar using keywords related to epistemology, proportional calistung, cognitive development, the theories of Jean Piaget, Lev Vygotsky, and Jerome Bruner, and loose parts. Sources were considered relevant when they addressed cognitive development in early childhood, the introduction of reading, writing, and arithmetic concepts, or the use of loose parts as learning media. Sources that did not address these themes were excluded from the analysis, while foundational theoretical works were retained on the basis of their relevance to the analytical framework, irrespective of their publication year.

Data were collected through documentation by identifying, reading, and classifying relevant information from the selected literature. The analysis was guided by three complementary theoretical perspectives. Piaget's theory was used to examine developmental readiness and the cognitive characteristics associated with the preoperational stage. Vygotsky's sociocultural theory informed the analysis of guided learning, the zone of proximal development (ZPD), and scaffolding. Bruner's theory of representation provided a framework for examining the progression from enactive to iconic and symbolic representation. These perspectives served as analytical criteria for exploring how calistung activities could be introduced in accordance with children's developmental readiness. Natural loose parts, including stones, seeds, leaves, and twigs, were examined as potential mediating materials through which children could engage in concrete manipulation, develop visual representations, and gradually connect their experiences with letters and numerical symbols.

The collected information was analyzed using qualitative content analysis through three stages: data reduction, data display, and conclusion drawing. During data reduction, relevant statements and findings were identified and classified according to the three analytical criteria: developmental readiness, guided learning through the ZPD and scaffolding, and progression across enactive, iconic, and symbolic representation. During data display, the classified information was compared and synthesized to identify conceptual relationships among the three theoretical perspectives and their implications for proportional calistung instruction using natural loose parts. In the final stage, conclusions were drawn by integrating theoretical interpretations and relevant empirical findings into a conceptual account of developmentally appropriate literacy and numeracy stimulation in early childhood. Because this study relied on published literature and did not involve direct observation or experimental testing, its findings were interpreted as a conceptual synthesis rather than evidence of the causal effectiveness of loose-parts-based calistung instruction. Furthermore, because some theoretical interpretations were informed by secondary sources, the analysis may reflect the interpretive perspectives of the authors of those sources. These limitations were considered when formulating the conclusions and recommendations for future empirical research..

3. RESULTS AND DISCUSSION

From an epistemological perspective, proportional calistung can be examined through three aspects: the source of knowledge (how children come to know letters and numbers), the validity of knowledge (what makes their understanding meaningful rather than rote), and the limits of cognitive capacity (what children can process at a given stage). In this study, proportional calistung means providing balanced reading, writing, and arithmetic stimulation that is matched to a child's cognitive readiness, so that it fosters readiness to learn rather than academic acceleration. The three classical theories address these aspects in complementary ways: Piaget mainly addresses the limits of cognitive capacity, Vygotsky the source of knowledge through guided interaction, and Bruner the validity of knowledge through the sequence of representation.

First, from Jean Piaget's perspective, children are viewed as "little scientists" who actively construct their own knowledge through interactions with their surrounding environment. This process unfolds dynamically and adaptively alongside the child's biological maturation. Jean Piaget posited that cognitive

development occurs across four universal and sequential stages: the sensorimotor stage (0–2 years), preoperational stage (2–7 years), concrete operational stage (7–11 years), and formal operational stage (11 years and above). During the preoperational stage, young children are not yet capable of understanding abstract concepts. Optimal learning occurs when instruction is implemented within concrete and realistic contexts, supported by media that can visually represent concepts in tangible ways to help children actively make sense of the world. . (Banat dkk., 2026) Furthermore, the principles of Piaget's constructivist theory emphasize a learning process that prioritizes student agency and active involvement. (Nasir, 2022) Based on this explanation, the implementation of proportional reading, writing, and arithmetic (calistung) for early childhood can be understood as follows: teachers or facilitators should not merely transfer knowledge passively; instead, they must help children construct their own understanding through direct interaction with their environment, enabling active participation in the learning process. Furthermore, introducing letters and numbers does not always require worksheets (LKS). Children need concrete media to help them construct the meaning behind these symbols. Loose parts learning media utilizing natural materials—such as stones, wood, shells, and seeds—serve as these constructive materials. Activities such as arranging stones or seeds to form letters and numbers, classifying leaves by size and color, or seriating twigs from shortest to longest represent early conceptual construction of proportional literacy and numeracy, turning abstract concepts into concrete experiences tailored to the child's cognitive development stage.

From Lev Vygotsky's perspective, his theory emphasizes social, sociocultural-historical, and individual interactions as the keys to human development. According to Vygotsky, there are four core concepts or theoretical focal points: sociocultural context, the zone of proximal development (ZPD), scaffolding, and language and thought (Wardani dkk., 2023).

- The sociocultural approach relies on social interaction, environment, and culture. Rooted in Lev Vygotsky's theory, it posits that social and cultural interactions surrounding an individual—rather than factors restricted solely to a classroom setting—shape learning and cognitive development. (Hidayat dkk., 2024)
- The Zone of Proximal Development (ZPD) is the distance between what a child can perform independently (actual developmental level) and what they can achieve with guidance or collaboration from an adult or a more capable peer (potential developmental level). (Ma'mun dkk., 2024)
- Scaffolding is temporary assistance provided by a mentor (a teacher or an adult) to a child during the learning process. This support is tailored to the child's needs and is gradually reduced as the child's independence increases. Scaffolding creates a safe learning environment where children feel supported to experiment and think independently without fear of making mistakes.
- According to Vygotsky, language and thought are essential in social interaction. These interactions can occur between individuals, between an individual and a group, or between groups through language. Sociocultural theory emphasizes that effective interaction between teachers and students must be built through language. Language is not merely a tool for communication, but also a means to build understanding and convey ideas. (Khoirunnisa dkk., 2025)

The implementation of proportional reading, writing, and arithmetic (calistung) for early childhood aligns directly with the concepts of Scaffolding and the Zone of Proximal Development (ZPD). Here, calistung instruction becomes disproportional when teachers demand that children reach their potential ability without providing adequate support. Conversely, proportional calistung creates a balanced approach by incorporating structured assistance tailored to the child's ZPD. Therefore, the open-ended nature of loose parts media—which lacks a single fixed way of use—serves as a flexible tool for step-by-step scaffolding. For instance, when a child struggles to count numbers, the teacher can assist by co-counting shells or seeds together, gradually fading support until the child can count independently. Similarly, to foster letter recognition, a teacher can guide children to arrange leaves along the outline of a letter, trace the letter's shape on sand using a stick, and then hunt for hidden letter shapes

throughout the environment. Once found, the child reinforces their understanding by identifying it—for example, recognizing that the hidden shape is the letter "A." Through this process, the teacher creates a learning experience aligned with the child's ZPD, offering scaffolding that leads the child from constructing shapes to searching, repeating, and ultimately understanding symbol forms. Thus, the teacher's role is not to impose arbitrary targets, but to bridge the child's readiness in processing learning concepts.

From Jerome Bruner's perspective, children undergo three cognitive development stages when representing knowledge: enactive, iconic, and symbolic. The enactive stage involves understanding through direct action or physical activity, the iconic stage relies on images or visual representations, and the symbolic stage operates through language or abstract symbols. These three modes of representation indicate that learning should align with how children process information, utilizing diverse forms of presentation to maximize instructional effectiveness. (H dkk., 2026) In the context of proportional reading, writing, and arithmetic (calistung) instruction, the use of loose parts learning media aligns with early childhood cognitive development stages, bridging abstract symbols—such as letters and numbers—with concrete experiences. During the enactive stage, learning occurs through direct action and physical manipulation of loose parts. Children touch and process natural materials through various hands-on activities, such as grouping, measuring, and classifying objects. This allows them to physically hold, feel textures, and manipulate natural resources. In the iconic stage, children transition to visual representation. Because the materials used—such as stones, seeds, and leaves—are drawn from their immediate environment, children are already familiar with them. This existing familiarity makes it easier for children to form mental images and visualize these objects. Finally, in the symbolic stage, having physically manipulated and visually represented the materials, children construct a meaningful bridge from the concrete to the abstract. They transition from an inability to grasp symbols to actively conceptualizing and internalizing the forms of letters and numbers. Without the foundational enactive experience provided by loose parts, introducing abstract symbols risks becoming an overly difficult and meaningless rote memorization exercise.

The convergence of these three theoretical perspectives—Piaget, Vygotsky, and Bruner—demonstrates that proportional reading, writing, and arithmetic (calistung) instruction relies on concrete exploration aligned with Piaget's preoperational stage, proportional guidance through Vygotsky's scaffolding within the Zone of Proximal Development (ZPD), and Bruner's sequential progression from enactive tactile manipulation to symbolic understanding. Consequently, loose parts learning media serve as an optimal solution. Loose parts are open-ended materials that can be manipulated, combined, rearranged, moved, separated, and reassembled in multiple ways, providing children with an experimental play environment that yields unlimited play possibilities driven by their imagination. By interacting with loose parts, children enter a "what if" mindset that fosters problem-solving capabilities and early theoretical thinking. Children's natural curiosity is organically supported by the availability of loose parts in their immediate surroundings, which can include natural materials, plastics, metals, wood, recycled packaging, and other accessible items. (Haryanto & Twiningsih, 2024) In the context of early childhood education, proportionality is defined as a harmonious balance between play and learning, aligned with a child's cognitive development stage. Thus, proportional calistung (reading, writing, and arithmetic) instruction provides a balanced level of stimulation through loose parts learning media—neither overstimulating nor neglecting fundamental developmental stages. Play is facilitated using loose parts media, while stimulation is structured around child development stages grounded in the foundational theories of Piaget, Vygotsky, and Bruner.

Existing empirical studies point in the same direction but remain limited. Using classroom action research with children aged 5–6, Aliyah and Nurajizah (2025) reported that literacy and numeracy skills rose from a low category (25.46%) to 100% after three cycles. Using a pretest–posttest design with 23 Group A children, Maulida et al. (2024) reported increases in the high category (15% to 46.8%) and the very high category (5% to 37.63%), with a significant paired t-test ($p < 0.001$). Weni et al. (2026) developed and tested a loose-parts-based integrative literacy model with 35 children aged 5–6 and

reported that mean reading scores rose from 44.12% to 82.8%. These findings are consistent with the view that natural loose parts can support early numeracy and literacy. However, they come from small, single-site samples, mostly lack control groups, and concern children aged 5–6. They therefore cannot establish causal effectiveness or speak to younger children in the preoperational stage, and are treated here as supporting illustrations rather than proof.

Table 1. *Cognitive Limit Analysis*

Mode of representation	Cognitive emphasis	Teacher scaffolding	Example activity	Observable learning indicator
Enactive	Direct manipulation of concrete objects	Demonstrates and counts together with the child	Counting seeds or shells	Child manipulates and groups objects before being asked to use numerals
Iconic	Visual representation of familiar objects	Gradually reduces prompts	Arranging leaves along a letter outline	Child recognizes or reproduces a visual pattern
Symbolic	Connecting concrete experiences to written symbols	Provides prompts when needed	Identifying a letter formed in sand	Child begins to associate a symbol with a concrete learning experience

4. CONCLUSION

This study shows that calistung need not be avoided; rather, it should be introduced proportionally. Read together, Piaget, Vygotsky, and Bruner suggest that proportional calistung (1) matches the concrete thinking of preoperational children, (2) provides adjustable guidance within the zone of proximal development that is gradually withdrawn, and (3) moves from enactive to iconic to symbolic representation. Natural loose parts such as stones, seeds, leaves, and twigs are conceptually consistent with these principles because they allow manipulation, visualization, and a gradual transition to letter and number symbols. For practice, this implies that early childhood educators can replace worksheet-first instruction with concrete, play-based activities that lead step by step toward symbols. This study is a literature review and relies partly on secondary interpretations of the three theories, so its framework remains conceptual. Future research should test proportional calistung models empirically, ideally with comparison groups and with attention to different ages within early childhood.

AI USAGE STATEMENT

During the preparation of this manuscript, the author used ChatGPT to assist with translation from Indonesian into English and language editing. The author reviewed and edited the translated content as needed and takes full responsibility for the content of this publication.

REFERENCES

- 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. *Jurnal Pendidikan Islam Anak Usia Dini: Anaking*, 3(2), 48–57. <https://doi.org/10.37968/anaking.v3i2.755>
- Banat, A., Ulfa, N., Salamah, S. S., Idawati, K., & Setyowati, D. (2026). *Perkembangan peserta didik sekolah dasar*. Yayasan Pendidikan Hidayatun Nihayah (Penerbit HN Publishing).
- Bruner, J. S. (1966). *Toward a theory of instruction*. Harvard University Press.
- Farikhah, S., & Ariestina, H. (2020). Menelisik kurikulum PAUD: Kajian fenomenologis terhadap kecenderungan belajar calistung anak usia dini. *Preschool: Jurnal Perkembangan dan Pendidikan Anak Usia Dini*, 1(2), 77–94. <https://doi.org/10.18860/preschool.v1i2.9058>

- Haryanto, F. T., & Twiningsih, A. (2024). Implementasi media loose parts pada pendidikan anak usia dini. *Edukara: Jurnal Pendidikan dan Pembelajaran*, 9(2), 54–64. <https://doi.org/10.32585/edukara.v9i2.362>
- Hidayat, A., Kulsum, U., Adibah, I. H., & Damayanti, D. D. (2024). Teori Vygotsky dan transformasi pembelajaran matematika: Sosiokultural, scaffolding, zona perkembangan proksimal, bahasa dan pikiran. https://www.researchgate.net/publication/387089683_Teori_Vygotsky_Dan_Transformasi_Pembelajaran_Ma_tematika_Sosiokultural_Scaffolding_Zona_Perkembangan_Proksimal_Bahasa_Dan_Pikiran
- Khoirunnisa, E., Zahra, Z. N., Nuruddin, R. I., & Riska, N. E. (2025). Analisis penerapan Zone of Proximal Development (ZPD) dalam pembelajaran. *Jurnal Pengembangan dan Evaluasi Pendidikan*, 2(3), 114–119. <https://doi.org/10.61692/jpep.v2i3.439>
- Ma'mun, A. A. J. M., Handayani, N. S., & Munawarah, H. (2024). Konsep Zone of Proximal Development (ZPD) dalam permainan anak-anak. *Jurnal Tumbuh Kembang Anak Usia Dini*, 2(1), 1–10. <https://journal.unupurwokerto.ac.id/index.php/tumbang/article/view/296/202>
- Maulida, S., Itsaniyah, S. M. U., & Utami, L. D. (2024). Pengaruh media loose parts pada pengembangan numerasi anak kelompok A di TK Ma'arif II Desa Lemahbang Kecamatan Sukorejo Kabupaten Pasuruan. *SELING: Jurnal Program Studi PGRA*, 10(1), 102–111. <https://doi.org/10.29062/seling.v10i1.2748>
- Nadhifah, S., & Aisyah, E. N. (2025). Pembelajaran calistung pada anak usia dini: Kajian fenomenologis terhadap dampak emosional dan perkembangan anak. *Jurnal QOSIM: Jurnal Pendidikan Sosial & Humaniora*, 3(4), 1745–1750. <https://doi.org/10.61104/jq.v3i4.2809>
- Nasir, M. A. (2022). Teori konstruktivisme Piaget: Implementasi dalam pembelajaran Al-Qur'an Hadis. *JSG: Jurnal Sang Guru*, 1(3), 215–223. <https://ejournal.uinib.ac.id/jurnal/index.php/jsg/article/view/5337>
- Pajriani, T. R., Nirwani, S., Rizki, M., Mulyani, N., Ariska, T. O., & Harahap, S. S. A. (2023). Epistemologi filsafat. *Primer: Jurnal Ilmiah Multidisiplin*, 1(3), 282–289. <https://doi.org/10.55681/primer.v1i3.144>
- Piaget, J. (1952). *The origins of intelligence in children*. International Universities Press.
- Putri D. H, A., Fuad, M. Z., Ismaya, S. D., & Abu Bakar, M. Y. (2026). Pendekatan teori konstruktivistik dalam pembelajaran. *Jurnal Ilmiah Penelitian Mahasiswa*, 4(3), 424–441. <https://doi.org/10.61722/jipm.v4i3.2398>
- Reghita, N. P. S., & Hariyanti, D. P. D. (2023). Efektifitas penggunaan media loose parts dalam meningkatkan kemampuan literasi numerasi anak usia dini. *Seminar Nasional PGPAUD 2023 "Transisi PAUD ke SD yang Menyenangkan."* Universitas PGRI Semarang. <https://conference2.upgris.ac.id/index.php/snpaud/article/view/18>
- Republik Indonesia. (2003). *Undang-Undang Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional*.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Wardani, I. R. W., Zuani, M. I. P., & Kholis, N. (2023). Teori belajar perkembangan kognitif Lev Vygotsky dan implikasinya dalam pembelajaran. *DIMAR: Jurnal Pendidikan Islam*, 4(2), 332–346. <https://doi.org/10.58577/dimar.v4i2.92>
- Weni, P. W. P., Sufa, F. F., & Wahyuseptiana, Y. I. (2026). Pengembangan model pembelajaran literasi integratif berbasis loose parts (LILP) untuk meningkatkan kemampuan membaca anak usia 5–6 tahun di TK Harapan Umat. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 11(2), 213–224. <https://doi.org/10.23969/jp.v11i02.44653>
- Whildan, L. (2021). Analisis teori perkembangan kognisi manusia menurut Jean Piaget. *Permata: Jurnal Pendidikan Agama Islam*, 2(1), 11–22. <https://doi.org/10.47453/permata.v2i1.245>