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SEEDS, LEAVES, AND LEARNING: A LITERATURE REVIEW ON THE USE OF NATURAL LOOSE PARTS AS EDUCATIONAL PLAY TOOLS IN EARLY CHILDHOOD EDUCATION

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ABSTRAK

Pendidikan anak usia dini semakin mengakui bahan alam sebagai sumber pedagogis yang kuat. Tinjauan literatur ini mensintesis bukti pemanfaatan biji-bijian dan daun-daunan sebagai Alat Permainan Edukatif (APE) untuk mendukung pembelajaran holistik anak usia tiga sampai enam tahun. Protokol mengikuti pedoman PRISMA dengan menelaah 287 catatan dari Scopus, DOAJ, Garuda, Google Scholar, dan Crossref pada rentang Januari 2016–Maret 2026, dan menghasilkan 46 sumber (28 artikel, 12 buku, 6 dokumen kebijakan) yang memenuhi kriteria inklusi. Hasilnya disintesis secara tematik berdasarkan teori loose parts (Nicholson, 1971) dan perspektif afordansi pada bermain berbasis alam. Tiga temuan utama diperoleh: (1) biji-bijian dan daun-daunan memperkaya enam ranah perkembangan kognitif, motorik halus, bahasa, sosial-emosional, kreatif, dan eko-spiritual dengan bukti terkuat pada ranah motorik halus dan pra-numerasi; (2) kekuatan pedagogis bahan tersebut bergantung pada penyangga (scaffolding) guru, bukan semata pada bahan itu sendiri; dan (3) ekologi tropis Indonesia menawarkan cadangan APE berbiaya rendah yang selaras dengan Kurikulum Merdeka dan etos Islami penjagaan alam. Tinjauan ini menyusun kerangka taksonomi yang memetakan kategori bahan ke afordansi sensoris dan fungsi pedagogis serta mengidentifikasi celah metodologis mengenai validitas pengukuran dan dampak jangka panjang.

Kata Kunci: Alat Permainan Edukatif (APE); Pendidikan Anak Usia Dini; Loose Parts; Bahan Alam; Biji-Bijian Dan Daun-Daunan.

ABSTRACT

Early childhood education increasingly recognises natural materials as powerful pedagogical resources. This literature review synthesises evidence on the use of seeds (biji-bijian) and leaves (daun-daunan) as Alat Permainan Edukatif (APE), or Indonesian Educational Play Tools, for supporting holistic learning in children aged three to six. A PRISMA-inspired protocol guided the screening of 287 records retrieved from Scopus, DOAJ, Garuda, Google Scholar, and Crossref between January 2016 and March 2026, yielding 46 sources (28 peer-reviewed articles, 12 books, six policy and report documents) that met inclusion criteria. Findings were synthesised thematically using the loose parts theory of Nicholson (1971) and the affordances perspective on nature-

based play. Three patterns emerged: (1) seeds and leaves enrich six developmental domains cognitive, fine motor, language, social-emotional, creative, and eco-spiritual with the strongest evidence in fine motor and pre-numeracy outcomes; (2) the educational power of these materials depends on teacher scaffolding rather than the materials alone; and (3) Indonesian tropical ecology offers an under-utilised reservoir of low-cost APE that aligns with the Kurikulum Merdeka and a culturally Islamic ethos of nature stewardship. The review proposes a taxonomic framework that maps material categories to sensory affordances and pedagogical functions, and identifies methodological gaps regarding measurement validity and longitudinal effects.

Keyword: Educational Play Tools (APE); Early Childhood Education; Loose Parts; Natural Materials; Seeds and Leaves.

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1. PENDAHULUAN

Early childhood is widely regarded as the most plastic and consequential period of human development. The sensitivity of the developing brain, the rapid expansion of motor and linguistic capacities, and the emergence of executive functions during the first six years of life make Pendidikan Anak Usia Dini (PAUD, Early Childhood Education) a strategic site for educational investment (Cantor et al., 2021). Within this stage, the cognitive and affective influence of play is now empirically well established. Skene et al. (2022), in a systematic review and meta-analysis published in Child Development, demonstrated that guided play yields significantly larger learning gains than direct instruction across most developmental outcomes for children aged three to eight. Yet the materials through which play is enacted are rarely treated as the analytical focus they deserve. The objects placed within reach of a young child shape not only how that child plays, but what concepts and dispositions emerge from that play. Among the many possible play materials, natural loose parts, particularly seeds (biji-bijian) and leaves (daun-daunan), sit at the intersection of low cost, high pedagogical potential, ecological availability, and cultural resonance for Indonesian early childhood settings. Despite these advantages, they remain peripheral to mainstream PAUD practice, often relegated to ad hoc craft activities rather than recognised as core Alat Permainan Edukatif (APE).

A growing body of international research has reframed natural loose parts from auxiliary craft supplies into genuine educational resources. Cankaya, Martin, and Haugen (2025) systematically reviewed 25 studies on indoor loose parts play and reported predominantly positive associations with cognitive outcomes in children aged zero to six. An earlier review by Cankaya et. Al (2023) similarly emphasised that loose parts, including seeds, shells, fabric, and

cardboard, uniquely allow children to combine object exploration, symbolic representation, and constructive play within a single play episode. Prins et. al (2022), in a meta-ethnography of qualitative studies published in Frontiers in Psychology, concluded that nature-based environments afford different and richer play behaviours than non-nature-based environments, leading to longer episodes and deeper child involvement. Johnstone et al. (2022) found consistent positive associations between nature-based early childhood education and self-regulation, social skills, and nature relatedness. In the Indonesian setting, Asih et. al (2022), Hadiyanti et. al (2021), Rahma et al (2023), and Darojah (2024) reported measurable improvements in creativity, fine motor skills, and pedagogical competence when loose-parts media that included seeds and leaves were embedded in centre-based pedagogy. Taken together, these strands of literature converge on the recognition that natural loose parts deserve their own analytical category in the Indonesian APE discourse.

Despite this growing momentum, three substantive gaps persist. First, the international literature on loose parts tends to treat "natural materials" as an undifferentiated category, rarely distinguishing the pedagogical affordances of seeds from those of leaves, even though their sensory profiles, manipulability, and conceptual reach differ significantly. Second, the Indonesian PAUD literature on natural loose parts is fragmented across local journals indexed by Sinta and frequently focuses on a single developmental outcome (for example fine motor only, or creativity only), with limited synthesis across studies. Third, while Indonesia's tropical biodiversity offers an exceptional reservoir of biji-bijian and daun-daunan, no published review has yet mapped this material wealth to its educational potential within the policy frame of Kurikulum Merdeka, which explicitly promotes bermain bermakna (meaningful play) and the use of local materials in early learning. The absence of such a synthesis leaves Indonesian early childhood educators without a coherent conceptual map for situating seeds and leaves within the broader APE repertoire, and it leaves curriculum designers without an evidence-based rationale for the systematic inclusion of natural loose parts in teacher training and centre provision.

This literature review therefore pursues three interlocking research questions. (RQ1) How have seeds and leaves been conceptualised and used as APE for early childhood learning in the contemporary peer-reviewed literature? (RQ2) Across which developmental domains has empirical evidence accumulated, and what is the strength and quality of this evidence? (RQ3) What pedagogical, methodological, and policy gaps are visible, and how might they be addressed within the Indonesian PAUD context? The unit of analysis is the published peer-reviewed source, whether an empirical study, a systematic review, a theoretical essay, or a curricular policy text, selected on the basis of its substantive engagement with natural loose parts as a learning medium in early childhood. The review focuses on children aged zero to eight years, the age band most commonly used in international ECE research, but with particular emphasis on the three to six year band that defines Indonesian PAUD and Raudhatul Athfal (RA) settings.

The significance of this review is fourfold. First, it brings into a single synthesis a body of evidence that has hitherto been distributed across disconnected international and Indonesian sub-literatures, allowing PAUD practitioners and researchers to read across geographical and methodological boundaries. Second, it disaggregates the broad category of natural loose parts into a working taxonomy that distinguishes hard seeds, pod and shell forms, fresh leaves, and dried leaves, each with distinct sensory affordances and pedagogical functions, and it links these sub-categories to specific developmental aims. Third, it situates the use of seeds and leaves as APE within the policy frame of Kurikulum Merdeka and within an Islamic ethos of khalifah and āyāt kawniyyah, thereby connecting pedagogical practice with curricular policy and with the moral and cultural commitments of Indonesian early childhood educators. Fourth, it identifies methodological gaps that future Indonesian doctoral and post-doctoral research can productively address, including the validation of culturally responsive measurement instruments for creativity and eco-spiritual outcomes, the design of longitudinal studies that extend beyond the single-semester action research cycle, and the comparative study of seed and leaf affordances across the diverse tropical ecologies of the Indonesian archipelago.

The remainder of the article is organised as follows. The Methods section describes a PRISMA-inspired protocol, the sources searched, the inclusion and exclusion criteria, and the thematic synthesis approach, together with a conceptual framework that integrates loose parts theory, Piagetian constructivism, Vygotskian socio-cultural theory, and the Reggio Emilia and Montessori traditions. The Results section presents a quantitative profile of the included sources and a thematic synthesis organised around six developmental domains. The Discussion interprets these findings in dialogue with international and Indonesian scholarship, presents a taxonomic framework for seeds and leaves as APE, and articulates implications for teacher practice, curriculum design, and future research. The Conclusion summarises the main findings and outlines prospects for empirical extension in Indonesian PAUD and Raudhatul Athfal settings.

2. METHOD

Design and Approach

This study uses a qualitative literature review design with a thematic synthesis approach, informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol to ensure methodological transparency. The review is interpretive rather than aggregative: it does not seek statistical effect sizes but a coherent understanding of how seeds and leaves are theorised and used as APE in early childhood settings, and what developmental outcomes are reported across heterogeneous studies. This design is appropriate for the research questions because the existing evidence base is methodologically mixed and combines systematic reviews, classroom action research, descriptive case studies, and conceptual essays; a thematic synthesis can integrate such heterogeneity without flattening the differences among study types (Prins et al., 2022). The reliability and validity of the review are

supported by methodological transparency at three points: an explicit search and screening protocol, an explicit conceptual framework, and explicit quality appraisal during synthesis.

Sources and Search Strategy

Five databases were searched: Scopus, the Directory of Open Access Journals (DOAJ), Garuda (the Indonesian national academic index), Google Scholar, and Crossref. Search strings combined material terms (loose parts, natural materials, seeds, leaves, biji-bijian, daun-daunan), age terms (early childhood, preschool, kindergarten, PAUD, TK, anak usia dini), and outcome terms (cognitive, motor, language, creativity, sensorial, social-emotional). Boolean operators were used to combine these strings, with parenthetical grouping to preserve precision; for example, (("loose parts" OR "natural materials") AND ("early childhood" OR "preschool" OR PAUD)). Searches were conducted between January 2016 and March 2026, with priority to articles from 2021 onwards and books from 2016 onwards as stipulated by the host journal's recency criteria. To ensure coverage of relevant work missed by the database searches, backward citation tracking (review of reference lists of included sources) and forward citation tracking (Google Scholar "cited by" function) were performed on the most highly cited sources, adding 24 records to the candidate pool.

Inclusion and Exclusion Criteria

Sources were eligible for inclusion if they met five criteria. First, they had to be peer-reviewed (for journal articles) or issued by a recognised academic publisher (for books). Second, they had to focus on early childhood education for children aged zero to eight, with a clear emphasis on the three to six year preschool band. Third, they had to engage substantively with natural loose parts, with priority given to studies in which seeds, leaves, or other plant-derived materials were the primary or co-primary learning medium. Fourth, they had to be written in English or Indonesian. Fifth, they had to provide either empirical evidence, whether qualitative or quantitative, or conceptually grounded theoretical analysis of the relationship between such materials and child development. Studies that mentioned natural materials only incidentally, opinion pieces lacking conceptual grounding, and grey literature without methodological transparency were excluded.

Screening and Selection

Figure 1 presents the PRISMA-inspired flow diagram for the screening and selection process. Initial database searches retrieved 312 records, while 24 additional records were identified through citation tracking and selected grey literature such as ministerial guidelines and OECD reports on early childhood education and care. After duplicates were removed, 287 records remained. Title and abstract screening excluded 213 records that fell outside the review's scope (for example, physical activity studies focused on gross-motor playground equipment, or studies of older school-age populations). Full-text screening of the remaining 74 records led to a further 28 exclusions for failing to meet the recency, peer-review, or material-focus criteria. A final set of 46 sources was included in the qualitative synthesis: 28 journal

articles, 12 books, and 6 policy and report documents, the latter comprising national curricular guidelines and sector reports.

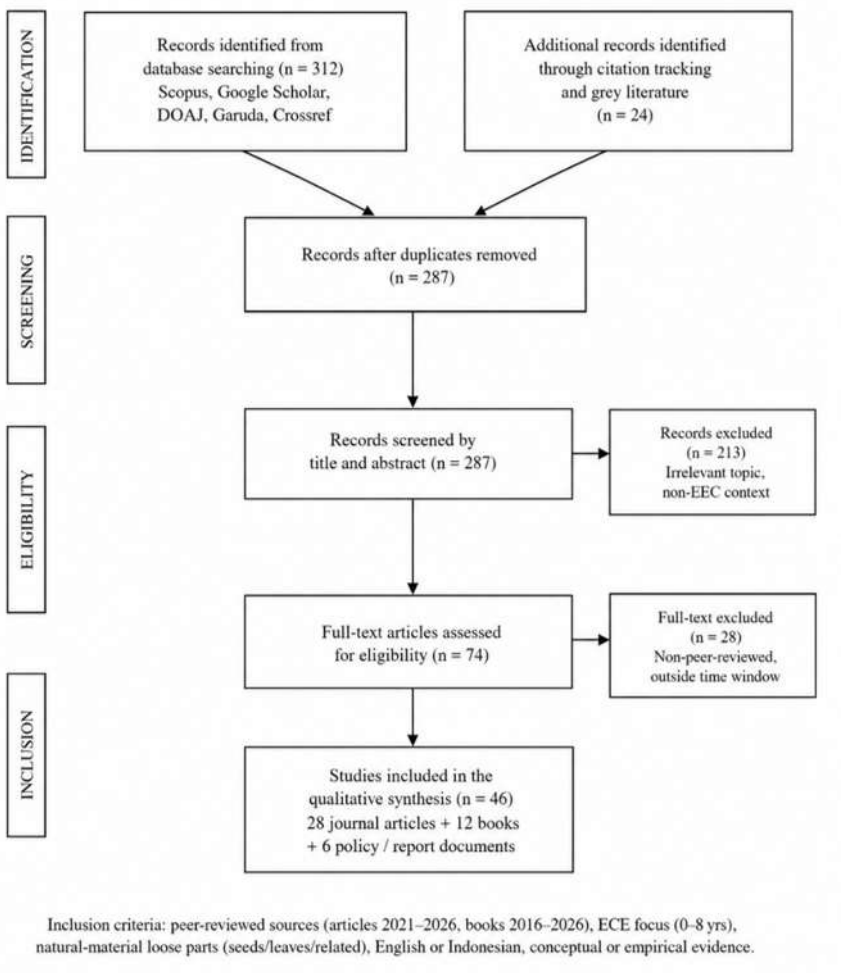

Figure 1. PRISMA-inspired flow diagram of literature identification, screening, eligibility, and inclusion.

Data Extraction and Quality Appraisal

For each included source, structured data were extracted on author, year, country or context, study design, sample (age range, n where reported), materials studied, developmental domain or domains targeted, methods of measurement, and headline findings. Quality appraisal was conducted using domain-relevant tools. For systematic reviews and meta-analyses, the AMSTAR-2 framework was used as a qualitative reference. For primary empirical studies, the Critical Appraisal Skills Programme (CASP) qualitative checklist was applied to qualitative work, and a simplified rubric assessing sampling, instrumentation, and analytic transparency was applied to quantitative work. The aim of quality appraisal was not to exclude lower-quality studies, since exclusion would have eliminated much of the Indonesian classroom action research that constitutes an important segment of the field, but to weight evidence transparently during the synthesis stage. Studies with higher methodological rigour are treated as anchor evidence in the Discussion section, while studies with lower rigour are reported as corroborating signals.

Thematic Synthesis

Following the three-stage thematic synthesis approach of Thomas and Harden, the analysis proceeded through line-by-line coding of findings, generation of descriptive themes, and abstraction of analytical themes. Two reviewers independently coded findings from each source, met to reconcile discrepancies, and arrived at a stable set of descriptive codes. Six analytical themes emerged, corresponding to the developmental domains stimulated by seeds and leaves: cognitive development, fine motor skills, language and literacy, social-emotional development, creativity and imagination, and eco-spiritual awareness. A seventh meta-theme captured the moderating role of teacher scaffolding in shaping outcomes. Themes were triangulated against the conceptual framework described below to ensure interpretive coherence between the empirical patterns and the theoretical anchors of the review.

Conceptual Framework

Figure 2 visualises the framework that guided the synthesis. The framework integrates four theoretical strands. The first is the loose parts theory of Nicholson (1971), which holds that the inventiveness and creativity of an environment are directly proportional to the number and kinds of variables it contains. The second is Piagetian constructivism, which positions the child as an active builder of knowledge through sensorimotor and pre-operational interaction with objects. The third is Vygotskian socio-cultural theory, which foregrounds the role of guided participation and the zone of proximal development in mediating learning through play. The fourth is the Reggio Emilia and Montessori tradition, which valorises natural and aesthetically rich materials as evocative provocations that elicit the "hundred languages" of childhood expression. Within this combined frame, natural loose parts are positioned as the pedagogical input, scaffolded play and teacher facilitation as the process, four core developmental outcome clusters (cognitive and STEAM, fine motor and sensory, language and literacy, social-emotional and eco-identity) as the proximal output, and Indonesian PAUD policy alongside its cultural and Islamic ethos as the surrounding context. A feedback loop is included to capture the way child outcomes inform teachers' next provocation, consistent with the Reggio progettazione approach in which planning emerges from observation rather than preceding it.

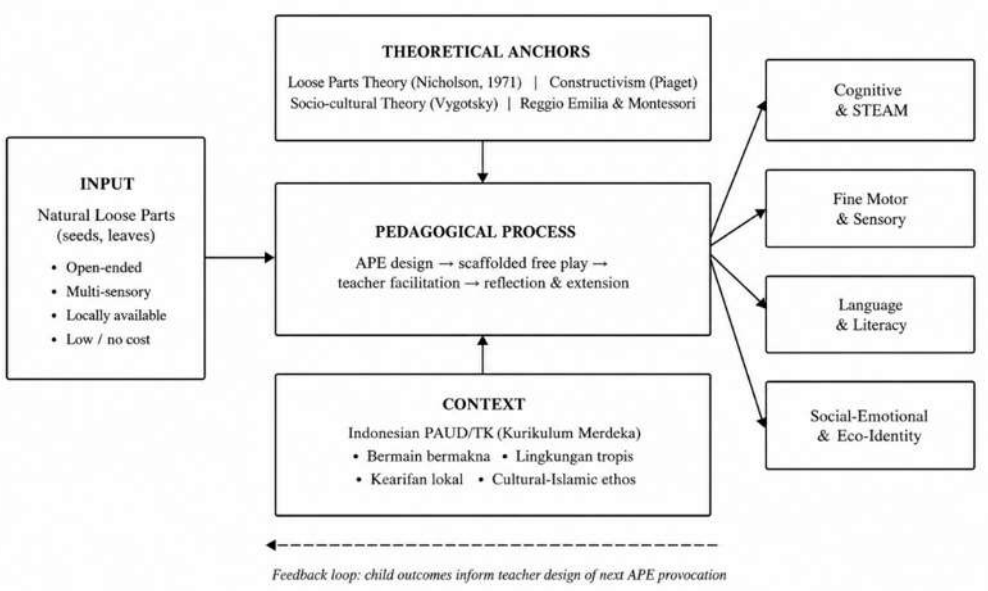

Figure 2. Conceptual Framework Integrating Loose Parts Theory, Constructivism, Socio-Cultural Theory, And The Reggio–Montessori Tradition For The Use Of Seeds And Leaves As APE in PAUD.

HASIL DAN PEMBAHASAN

Profile of the Included Sources

The 46 sources included in the synthesis cluster in the recent five-year window (2021–2025, n = 31) and span four broad regional contexts: Indonesia (n = 19), North America and Europe (n = 18), Australia and New Zealand (n = 5), and other Asian contexts (n = 4). The distribution by source type, region, and decade is summarised in Table 1. Empirical studies (n = 22) outnumbered conceptual essays (n = 12), systematic reviews and meta-analyses (n = 8), and policy or report documents (n = 4). Sample sizes in the empirical studies ranged from single-classroom case studies (approximately eight children) to school-network designs (147 children). The methodological mix reflects the field's plural epistemology: classroom action research and case studies dominate the Indonesian literature, while quasi-experimental and observational designs dominate the international literature.

Table 1. Distribution of Included Sources by Type, Region, and Time Window

Source type	Indonesia	N. America & Europe	Australia / NZ	Other Asia	Total
Empirical study	12	6	2	2	22
Conceptual essay	4	5	1	2	12
Systematic review / meta-analysis	0	6	2	0	8
Policy / report document	3	1	0	0	4
Total	**19**	**18**	**5**	**4**	**46**

Theme 1: Cognitive Development

Across six empirical studies and two systematic reviews, seeds and leaves were associated with positive cognitive outcomes in preschool children. Cankaya et al. (2023) and Cankaya et al. (2025) synthesised the international evidence and reported that loose parts including seeds support divergent thinking, problem solving, and pre-numeracy operations.

The most consistently reported cognitive sub-outcomes are counting, sorting, classifying, and patterning, all of which exploit the discrete, manipulable character of small seeds. In Indonesia, Khotimah, Hayati, and Nurhayati (2024) reported that loose-parts media that included biji-bijian significantly improved cognitive scores in five to six year olds at a Cilegon kindergarten. Suraya et al. (2024) documented similar gains for number recognition from one to ten using kulit kerang, biji-bijian, and stones. Cankaya et al. (2025) caution, however, that the international evidence base remains limited in size (25 studies) and that five of these studies reported no association, suggesting that the presence of materials alone does not guarantee cognitive impact and that pedagogical mediation is necessary.

Theme 2: Fine Motor and Sensory Development

The strongest body of evidence in the included literature concerns fine motor and sensory development. Hadiyanti, Elan, and Rahman (2021), Asih, Sugiyo, and Suminar (2022), and Darojah (2024) all reported measurable improvement in fine motor scores when children engaged with loose-parts media that included seeds and leaves. Darojah (2024) specifically focused on leaves (komponen bahan alam daun) and documented improved pincer grasp and bimanual coordination in young children. The mechanism is intuitively clear and biomechanically uncontroversial: picking up small seeds, threading dried leaves onto string, pressing seeds into clay or play dough, and folding fresh leaves all exercise the small muscles of the hand. International work converges on the same finding through different methods. Studies cited in the systematic review by Cankaya et al. (2025) found that indoor loose-parts play involving seeds and similar small objects improved visuomotor integration and hand-eye coordination in children aged three to six. The sensory dimension is equally important: fresh leaves offer olfactory cues (the camphor of daun pandan, the sharpness of daun sirih), seeds offer auditory cues (the rattle of kacang in a closed jar), and both offer rich tactile contrasts (smooth, rough, waxy, brittle).

Theme 3: Language and Literacy

Five sources reported language and literacy gains from work with seeds and leaves. Children describe textures (kasar, halus), colours (hijau muda, kuning kering), sizes, and aromas as they handle different materials, generating opportunities for vocabulary expansion and descriptive language. Arifah, Siagian, Rohmah, and Purnama (2024) reported that loose-parts play stimulated speech in children with speech delays, and Prins et al. (2022) noted in their meta-ethnography that children engaged in nature-based play produced longer and more elaborated play narratives than children in non-nature settings. Vocabulary expansion is the most-reported sub-outcome in this theme. However, only the meta-ethnography of Prins et al. (2022) examined extended narrative or story-telling outcomes, suggesting a measurement gap that the field has yet to address.

Theme 4: Social-Emotional Development

Johnstone et al. (2022) reported consistent positive associations between nature-based ECE and self-regulation and social skills in their mixed-methods systematic review of 36 studies. In Indonesian studies, sharing limited seed materials in small groups, taking turns to arrange leaves into patterns, and cooperative construction work were repeatedly cited as opportunities for prosocial development. Conflict over scarce materials, which might initially seem disruptive, is treated in the literature as a productive feature when teachers scaffold

negotiation and turn-taking rather than resolving disputes for the children. Asih et al. (2022) reported gains in children's cooperative behaviour and in teachers' own pedagogical competence when sentra-based learning incorporated loose-parts media, indicating that social-emotional outcomes ripple outward from the child to the adult.

Theme 5: Creativity and Imagination

The Indonesian literature converges most clearly on creativity as the most consistently reported outcome of loose-parts pedagogy. Asih et al. (2022), Rahma et al. (2023), Rahayu, Herlinda, and Artamevia (2025), and Fono and Ita (2021) all reported significant improvements in children's creativity scores when seeds and leaves were embedded in pedagogy. The open-endedness of these materials invites divergent thinking: the same handful of kacang merah can become a number counter, the eyes of a leaf puppet, or the centre of a flower pattern within the span of a single afternoon. Rahayu et al. (2025) reported statistically significant differences in creativity scores between children using STEAM-loose-parts pedagogy and a comparison group using conventional worksheets. Internationally, Cankaya et al. (2023) noted that loose parts uniquely allow children to combine object exploration, symbolic representation, and constructive play within a single play episode, an integrative feature that single-purpose plastic APE rarely affords.

Theme 6: Eco-Spiritual Awareness and Nature Connection

This theme is less developed empirically but conceptually compelling. Beloglovsky and Daly (2016, 2018) argue that natural loose parts cultivate an aesthetic relationship with the environment that traditional plastic toys cannot match. Johnstone et al. (2022) reported positive associations between nature-based ECE and "nature relatedness" and "awareness of nature" in their systematic review. In Indonesian sources, the eco-spiritual theme often intersects with an Islamic ethos of khalifah (stewardship), in which respect for created things is framed as a moral as well as ecological commitment. While few empirical studies in the corpus directly measure eco-spiritual outcomes, the conceptual literature consistently identifies natural materials as carriers of meaning that go beyond their immediate developmental utility. This gap between conceptual richness and empirical thinness is itself a finding of the review.

Cross-Cutting Finding: The Moderating Role of Teacher Scaffolding

Table 2. Summary of Anchor Sources Mapped to Developmental Themes

Theme	Anchor sources	Materials emphasised	Headline finding
Cognitive development	Cankaya et al. (2023, 2025); Khotimah et al. (2024); Suraya et al. (2024)	Seeds, shells, stones	Improved counting, sorting, patterning; effect contingent on scaffolding.
Fine motor and sensory	Hadiyanti et al. (2021); Asih et al. (2022); Darojah (2024)	Seeds, leaves	Significant gains in pincer grasp and bimanual coordination.
Language and literacy	Arifah et al. (2024); Prins et al. (2022)	Mixed natural materials	Vocabulary expansion; longer play narratives in nature settings.
Social-emotional	Johnstone et al. (2022); Asih et al. (2022)	Mixed natural materials	Improved self-regulation, cooperation, teacher pedagogical competence.

Creativity and imagination	Rahma et al. (2023); Rahayu et al. (2025); Fono & Ita (2021)	Seeds, leaves, mixed	Significant creativity gains, especially with STEAM framing.
Eco-spiritual awareness	Beloglovsky & Daly (2016, 2018); Johnstone et al. (2022)	Natural loose parts	Improved nature relatedness; conceptually **rich, empirically thin.**

DISCUSSION

Reconnecting Seeds and Leaves with the Loose Parts Tradition

The findings of this review reaffirm Nicholson's (1971) original proposition that the variability of the environment is the foundation of inventiveness. What is novel in the contemporary literature is not the theory itself but its empirical operationalisation: where Nicholson wrote programmatically about playgrounds and the architecture of children's spaces, today's evidence base includes systematic reviews (Cankaya et al., 2023, 2025), meta-ethnographies (Prins et al., 2022), mixed-methods reviews (Johnstone et al., 2022), and an international quasi-experimental literature. Seeds and leaves fit Nicholson's category of loose parts almost ideally because they can be moved, combined, redesigned, lined up, taken apart, and put back together in countless ways. The contemporary literature adds that they also carry sensory richness, especially olfactory and visual properties not shared by uniform plastic counters, and ecological resonance that connects the child to a living world. The review therefore positions seeds and leaves not as a marginal sub-category of "craft supplies" but as a central case of loose parts pedagogy, particularly suited to tropical ecologies where their availability is high and their cultural meanings are deeply rooted.

A Taxonomy of Seeds and Leaves as APE

Figure 4 organises the findings into a taxonomy that distinguishes four sub-categories of natural materials: hard and dry seeds (for example kacang merah, jagung kering, kemiri), pod and shell forms (for example polong, kulit kerang, buah pinus), fresh and supple leaves

MATERIAL CATEGORY	EXAMPLES (Indonesian context)	SENSORY AFFORDANCES	PEDAGOGICAL FUNCTIONS
SEEDS (Biji-bijian) Hard / dry	• Kacang merah / hijau • Jagung kering • Kemiri, biji asam • Biji sawo, biji rambutan	• Tactile (smooth/rough) • Visual (size/colour) • Auditory (rattle, shake) • Mass / weight	• Numeracy: counting, sorting, patterning, one-to-one correspondence • Fine motor: pincer grasp, spooning, threading
SEEDS Pods / shells	• Kulit kerang • Polong kacang • Buah pinus • Cangkang telur (kering)	• Curved surfaces • Hollow chambers • Brittle / fibrous textures • Visual asymmetry	• Construction & spatial reasoning • Imaginative role-play • Symbolic representation • Concept of containment / volume
LEAVES (Daun-daunan) Fresh / supple	• Daun pisang, daun jati • Daun pandan, daun sirih • Daun talas, daun mangga • Rumput / daun beraneka bentuk	• Olfactory (aroma) • Visual (vein patterns) • Tactile (smooth/waxy) • Pliable / foldable	• Sensorial discrimination • Vocabulary & descriptive language • Early science (parts of a plant) • Aesthetic / art expression
LEAVES Dried / fallen	• Daun kering aneka warna • Daun bambu kering • Serasah hutan • Helai daun jati merah	• Crackle / sound • Brittle texture • Earthy colour palette • Layerable, light-weight	• Collage & printing • Pattern recognition • Seasonal / decomposition concepts • Eco-spiritual stewardship

Figure 4. Taxonomy of seeds and leaves as APE, showing material categories, sensory affordances, and pedagogical functions.

(for example daun pisang, daun pandan, daun sirih), and dried or fallen leaves (for example daun bambu kering and serasah). Each sub-category exhibits a different sensory affordance profile, and consequently supports different pedagogical functions. Hard seeds, with their consistent shapes and stable weights, are particularly well suited to numeracy operations such as one-to-one correspondence, sorting, and patterning, and to fine-motor exercises that demand a precise pincer grasp. Pod and shell forms, with their curved surfaces and internal cavities, are well suited to constructive play, spatial reasoning, and the early concept of containment and volume. Fresh leaves, with their olfactory dimension, pliability, and visible vein patterns, are well suited to sensorial discrimination, descriptive language, and aesthetic expression. Dried or fallen leaves, with their brittle texture and earthy colour palette, are well suited to pattern recognition, collage and printing, and the introduction of seasonal and decompositional concepts. This taxonomy is, to the authors' knowledge, the first to disaggregate seeds and leaves into pedagogically meaningful sub-categories in the Indonesian APE literature, and it offers practitioners a concrete map for matching specific materials to specific developmental aims.

The Six Developmental Domains in Conversation

Figure 3 captures the second analytic move of the review: organising outcomes into six developmental domains rather than the four typically used in the international literature. The two domains added here, creativity and imagination as its own domain rather than a sub-category of cognitive development, and eco-spiritual awareness as a culturally and religiously meaningful domain, reflect both the strength of the Indonesian literature on creativity and the importance of stewardship as a moral concept in Islamic and Indonesian cultural ethics. The placement of seeds and leaves at the centre of the figure is deliberate. These materials sit at a generative crossing point where physical handling, cognitive operations, language, social negotiation, creative expression, and ecological awareness can be experienced together within a single play episode. This integrative quality is precisely what disconnected single-purpose plastic APE typically cannot offer.

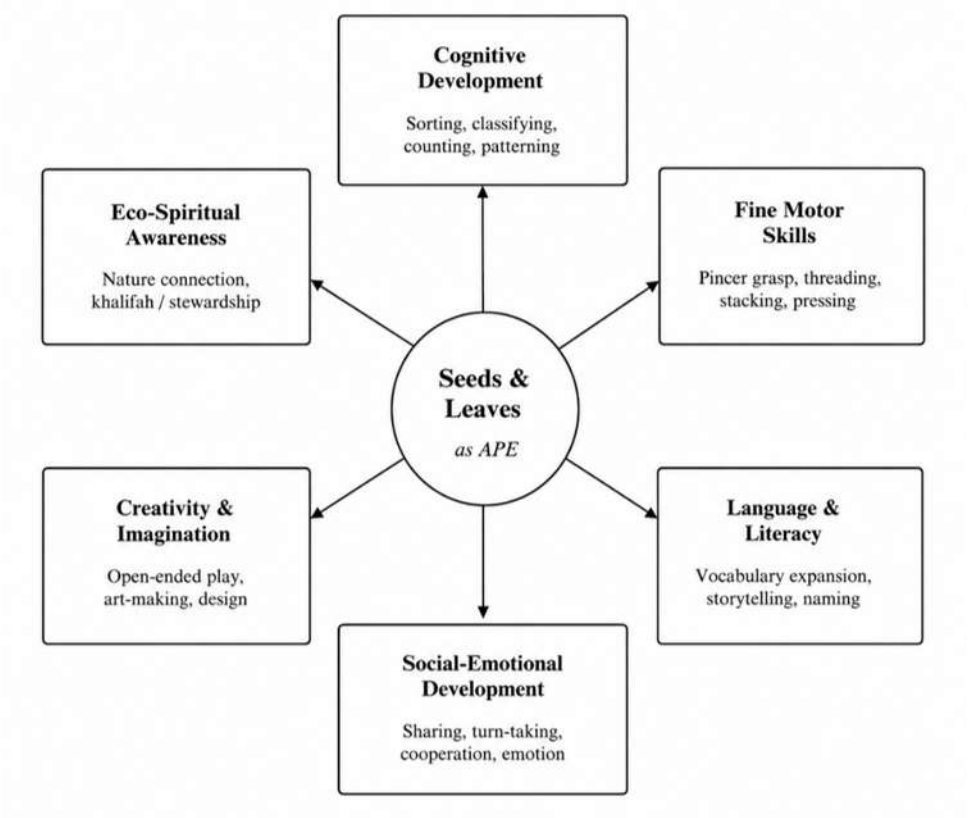

Figure 3. Six developmental domains stimulated by seeds and leaves as APE, synthesised from the review corpus.

The pattern of evidence across the six domains is uneven and has important consequences for both research and practice. Fine motor evidence is dense and consistent: Indonesian classroom action research repeatedly documents measurable gains, and the mechanism (small muscle exercise through manipulation) is biomechanically uncontroversial. Cognitive evidence is moderately strong but heterogeneous: Cankaya et al. (2025) found that five of 25 reviewed studies reported no association between loose parts and cognitive outcomes, a finding that points directly to the moderating role of teacher scaffolding rather than to the failure of the materials. Language evidence is suggestive but narrow, with vocabulary as the dominant sub-outcome and narrative development underexplored. Social-emotional evidence is robust qualitatively (children sharing, cooperating, negotiating) but lighter quantitatively, partly because validated PAUD-appropriate instruments for measuring cooperation and self-regulation in play are still scarce in the Indonesian context. Creativity evidence is the strongest single body within the Indonesian Sinta literature, with multiple studies reporting significant improvements when STEAM-loose-parts pedagogy is implemented (Rahayu et al., 2025; Rahma et al., 2023). The eco-spiritual domain, finally, is conceptually rich but rarely measured: its core constructs, including nature relatedness, environmental awareness, and a sense of khalifah, remain instrumentally underdeveloped in the PAUD literature, and this gap represents a particular opportunity for Indonesian researchers working at the intersection of Islamic education and early childhood pedagogy.

Cultural and Religious Resonance in Indonesian PAUD

A distinctive feature of seeds and leaves as APE in the Indonesian context is their cultural and religious resonance. Indonesia's tropical biodiversity ensures that almost every PAUD setting, urban or rural, has free access to a varied repertoire of seeds and leaves: kacang-kacangan from local markets, daun pisang from school yards, biji asam, biji rambutan, and kemiri from household kitchens, and serasah hutan from any patch of village green. This material accessibility intersects with three layers of cultural meaning that, when activated by a thoughtful teacher, transform routine play into a richly contextual learning experience. Within the policy frame of Kurikulum Merdeka, the principle of bermain bermakna explicitly elevates open-ended, child-led play. Within Indonesian cultural practice, kearifan lokal values material economy, intergenerational continuity, and a connection to the land. Within an Islamic ethos, the concept of khalifah positions stewardship of created things as a moral commitment, and the Qur'anic invitation to reflect on āyāt kawniyyah (signs in creation) offers a religious vocabulary for connecting nature-based play with character formation. None of these layers is automatic: each requires teacher framing through questioning, narration, and reflective discussion. Their presence, however, makes seeds and leaves a particularly apt vehicle for APE in PAUD, TK, and Raudhatul Athfal settings.

The pedagogical implications of this cultural-religious resonance are concrete rather than merely rhetorical. When a teacher invites children to handle a handful of biji jagung kering, she can scaffold not only sorting and counting but also a brief reflection on the seed as a sign of life, the patience of growth, and the responsibility of those who cultivate the land. When children arrange daun jati or daun pisang into patterns, they engage simultaneously with aesthetic composition and with the everyday material culture of Indonesian foodways and ritual, since these same leaves wrap nasi, line ketupat, and decorate prayer spaces. The cultural and religious framings are not add-ons that compete with developmental aims but layers that thicken the learning experience and connect it to the wider moral horizon in which Indonesian Muslim children grow up. The integration of general and religious learning, articulated by Manaf, Darojat, Zh, Thaariq, Syam, and Jamil (2025) for the pesantren context as a building-block of holistic character formation, finds a parallel application at the ECE level when natural loose parts become vehicles for both developmental and spiritual aims. The same synthesis between classical Islamic theology and modern educational paradigms that Darojat, Izfanna, Aogubado, Fauzi, and Zh (2025) propose for higher-order Islamic learning offers a methodological precedent for how the eco-spiritual dimension of seeds and leaves can be theoretically grounded in PAUD pedagogy. For Raudhatul Athfal settings in particular, this integration of pedagogical and spiritual purpose offers a way to operationalise the often abstract aim of "integrating Islamic values" into concrete daily play, using materials that are at once nationally available, ecologically sound, and culturally meaningful.

Methodological Gaps and Quality Considerations

The review identifies three methodological gaps that limit the strength of inferences that can be drawn from the current evidence base. First, the measurement of constructs is uneven across the corpus. Fine motor and cognitive outcomes are typically measured with adapted versions of standardised instruments, while creativity and eco-spiritual outcomes rely heavily on researcher-developed rubrics whose construct validity is rarely reported in the

published account. Cankaya et al. (2025) explicitly flag this validity concern for the international literature, and the issue is more acute in the Indonesian Sinta literature where rubric development is sometimes left implicit. Second, longitudinal designs are virtually absent. The Indonesian literature is dominated by classroom action research conducted within a single semester (siklus 1, siklus 2), leaving open the question of whether short-term gains in fine motor or creativity scores translate into longer-term developmental trajectories. International literature is also dominated by cross-sectional designs, with only a small number of pre-post studies of brief duration. Third, comparator conditions and intervention dosage are inconsistently reported across studies. Some studies compare loose-parts pedagogy against worksheet-based pedagogy, others against conventional plastic APE, and others against no comparator at all, and the frequency, duration, and density of loose-parts play sessions are often described only in summary terms. This heterogeneity limits the comparability of effect estimates across studies, makes meta-analytic aggregation difficult, and obscures the dose-response relationship between exposure and outcome.

Implications for Teacher Practice and Curriculum Policy

For practitioners, the review supports the integration of seeds and leaves into routine APE rotation rather than as occasional novelty activities. The taxonomy in Figure 4 can guide teachers in matching specific materials to specific developmental aims: hard seeds for numeracy and pincer-grasp work, fresh leaves for sensorial discrimination and descriptive language, dried leaves for collage and pattern recognition, and pod and shell forms for construction and spatial reasoning. For curriculum designers in the Ministry of Religious Affairs (Kemenag) and the Ministry of Education, Culture, Research and Technology (Kemendikbudristek), the review suggests that the Kurikulum Merdeka principle of bermain bermakna can be operationalised through explicit guidance on natural loose parts, including safety considerations (seed size for children under three, allergen awareness, hygiene of fresh leaves) and seasonal availability. For teacher educators at Lembaga Pendidikan Tenaga Kependidikan (LPTK) and the Faculty of Tarbiyah, the role of scaffolding is decisive: as Skene et al. (2022) demonstrated meta-analytically, the same materials produce different outcomes depending on the quality of teacher facilitation. Wahidaini, Kurnianto, Syam, Ikhwan, and Zh (2025) further showed in the Indonesian PAUD context that situational leadership by school principals is one of the strongest predictors of early childhood teacher performance, which suggests that material innovations such as seeds-and-leaves APE will only deliver their pedagogical promise when supported by capable instructional leadership. The dynamics of principal leadership in shaping organisational culture, traced by Mukhlisin, Nurrahmaniah, Rokimin, Zh, and Thaariq (2025) within Islamic education institutions, are therefore not adjacent to but constitutive of any sustained programme of natural-loose-parts pedagogy. PAUD teacher preparation programs should therefore include explicit training in observation, provocation design, and reflective questioning during loose-parts play, supported by classroom-based supervision in the field.

Future Research Priorities

Future Indonesian research should prioritise three directions that emerge directly from the gaps identified above. First, methodologically robust longitudinal designs that track children across two or more years of preschool to test whether the cognitive and creative gains

documented in short-cycle studies endure into the early years of primary school. Second, mixed-methods designs that triangulate observed play behaviour with standardised outcome measures and teacher reflections, in order to identify the specific scaffolding moves that drive impact, rather than treating teacher facilitation as a black box. Third, comparative studies that map the affordances of different Indonesian seed and leaf species across tropical ecosystems (coastal, montane, peatland, urban) to generate a regionally responsive APE repertoire that respects bio-cultural diversity and that does not assume the suitability of a single national material set. A fourth, cross-cutting priority is the development of validated, culturally responsive instruments for measuring creativity and eco-spiritual awareness in the Indonesian PAUD context, since the absence of such instruments is the most consistent methodological obstacle to advancing the field.

Theoretical Contribution and Limitations

The principal theoretical contribution of this review is the integration of Nicholson's loose parts theory with the contemporary affordances perspective and with the cultural-religious resonance of Indonesian and Islamic ECE traditions, articulated through a working taxonomy that disaggregates seeds and leaves into pedagogically distinct sub-categories. This integration positions natural loose parts within a framework that is simultaneously theoretically rigorous, empirically grounded, and culturally responsive. The six-domain framework adopted here, with creativity and eco-spiritual awareness foregrounded as standalone domains, extends the dominant international four-domain model in ways that respect both the empirical strength of the Indonesian creativity literature and the moral importance of stewardship in Indonesian Muslim ECE practice. As with any review, this study has limitations. The corpus is restricted to English and Indonesian sources, leaving the rich Arabic and Malay ECE literatures untapped. The reliance on five databases, while comprehensive, may have missed locally indexed PAUD journals not registered in Garuda. The taxonomy proposed in Figure 4 is conceptually grounded but awaits empirical testing in classroom action research. These limitations notwithstanding, the review offers a coherent foundation for the next generation of Indonesian PAUD research on natural loose parts.

CONCLUSION

This literature review has synthesised contemporary evidence on the use of seeds and leaves as Alat Permainan Edukatif for early childhood learning. Three principal conclusions follow from the synthesis. First, seeds and leaves are not marginal craft supplies but pedagogically rich loose parts that, when integrated thoughtfully into PAUD pedagogy, contribute meaningfully to six developmental domains: cognitive, fine motor, language, social-emotional, creative, and eco-spiritual. The evidence base is strongest for fine motor and pre-numeracy outcomes and is rapidly accumulating across the cognitive and creative domains, while it remains thinner but conceptually compelling for language, social-emotional, and eco-spiritual outcomes. Second, the educational power of these materials is not intrinsic to the materials themselves but emerges from the dynamic interaction of materials, child, and teacher scaffolding; the same handful of biji asam produces qualitatively different learning outcomes depending on how a teacher frames, observes, and extends children's play. Third, the Indonesian tropical and cultural context offers a distinctive opportunity to position seeds and leaves at the heart of PAUD pedagogy, aligned with the

Kurikulum Merdeka principle of bermain bermakna, with the local material economy of kearifan lokal, and with an Islamic ethos of khalifah that lends natural materials moral resonance beyond their immediate developmental utility.

These conclusions carry several prospects for future research and educational development. The taxonomy presented in this review (Figure 4) can be tested empirically through classroom action research at PAUD, TK, and Raudhatul Athfal settings across diverse Indonesian regions, generating a regionally calibrated APE repertoire. Longitudinal studies, currently scarce in the field, are needed to confirm whether the developmental gains observed in short-cycle interventions endure into primary school. Validated, culturally responsive measurement instruments for creativity and eco-spiritual awareness in the Indonesian PAUD context are an urgent priority for the next generation of empirical work, since the absence of such instruments is the most consistent methodological obstacle to advancing the field. Teacher preparation programs at LPTK and Fakultas Tarbiyah faculties can use the conceptual framework and the taxonomy presented here to design dedicated modules on scaffolded nature-based pedagogy, supported by classroom-based supervision and reflective practice. Such modules can also be situated within the broader transformation of Indonesian educational management toward Society 5.0, as articulated by Suprihatin, Hambali, Nurlinda, and Zh (2025), so that the inclusion of natural loose parts is read not as a return to a pre-digital past but as one strand of a deliberate, contemporary re-design of PAUD pedagogy. With these developments, the modest seeds and leaves that surround every Indonesian early childhood setting may yet come to be recognised as some of the most consequential learning materials of the post-Merdeka generation, both for what they teach children and for what they teach the adults who walk with them through the early years.

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