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Principles of Curriculum Design for Early Childhood Science Activities

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ABSTRACT: Curriculum design plays a pivotal role in shaping young children's science learning experiences and is often conceptualized as both the integration of children's diverse learning experiences and the tangible manifestation of the meanings they construct through learning. From this perspective, the content and design of science curricula implemented in early childhood settings warrant careful attention. The ways in which teachers design these curricula have a profound impact on learning outcomes. Grounding curriculum design in sound and developmentally appropriate educational principles enhances the likelihood of achieving broader educational objectives. Accordingly, this study aims to examine the core principles that early childhood teachers should consider when designing science education curricula. By adhering to these principles, teachers are expected to develop curricula that closely align with children's interests and everyday life experiences, thereby fostering developmentally appropriate learning opportunities. Such curricula not only support children's cognitive growth but also promote affective and social development, contributing to the holistic development of young learners. Based on this framework, the present study identifies three key principles of early childhood science curriculum design: (1) Experience-Based approaches to science learning in early childhood; (2) Emphasizing exploration and hands-on constructivist approaches; (3) Curriculum design for enhancing young children's thinking skills; and (4) Integrating multiple teaching strategies in the design of science activities for young children. Through examining these principles, this study seeks to contribute to the improvement of young children's scientific literacy and to provide practical guidance for early childhood teachers in designing meaningful and developmentally appropriate science learning experiences.

1.INTRODUCTION

As knowledge about human development and learning has expanded rapidly, opportunities to design more effective educational practices have likewise increased. Realizing the full potential of these advances, however, requires integrating insights from multiple fields—including biology and neuroscience, psychology, sociology, and the developmental and learning sciences—and connecting them with evidence-based approaches emerging from educational research (Darling-Hammond, Flook, Cook-Harvey, Barron & Osher, 2020). In the context of early childhood education, this interdisciplinary knowledge underscores the central role of curriculum in shaping children's learning experiences. During the developmental process in preschool settings, curriculum functions as a critical structure through which educational goals, teaching strategies, and children's developmental needs are aligned, making it a foundational element in promoting young children's holistic growth.

When the term 'curriculum' was originally linked to education in the C16th Europe, it denoted an ordered systematic framework for what is taught and learned. Four hundred years later, curriculum was still being defined as 'All the learning which is planned and guided'. However, it is important to note that these descriptions refer to the explicit curriculum, as distinct from the 'hidden curriculum', which is instrumental in the implicit reproduction of values and behaviours in schools. In C21st early childhood provision, the explicit curriculum may be described at its most prescriptive as the 'organised framework that delineates the content children are to learn, the processes through which children achieve the identified curricular goals, what teachers do to help children achieve these goals, and the context in which teaching and learning occur'(Hamilton1989; Jackson 1968; Kerr 1968; Murray, 2022; Petersen, Ahrenkiel, Jørgensen, 2025).

Curriculum design plays a pivotal role in the science learning experiences of young children and is often conceptualized as both the integration of children's diverse learning experiences and the tangible manifestation of the meanings they construct through learning. From this perspective, the content and design of science curricula implemented in early childhood settings warrant careful attention. The manner in which teachers design these curricula has a profound impact on learning outcomes. Grounding curriculum design in sound and developmentally appropriate educational principles enhances the likelihood of achieving broader educational objectives. Accordingly, this study aims to examine the core principles that early childhood teachers should consider when designing science education curricula. By adhering to these principles, teachers are expected to develop curricula that align closely with children's interests and everyday life experiences, thereby fostering developmentally appropriate learning opportunities. Such curricula not only support children's cognitive growth but also promote affective and social development, contributing to the holistic development of young learners (Balakrishnan, 2022; O'Connor, Fragkiadaki, Fleer & Rai, 2021; Shih, 2025a, 2025b, 2025c, 2025d; Zhang, H. & Chow, 2022).

2. PRINCIPLES OF CURRICULUM DESIGN FOR EARLY CHILDHOOD SCIENCE ACTIVITIES

2.1 Experience-Based Approaches to Science Learning in Early Childhood

In *Democracy and Education*, John Dewey elaborates on the nature of experience, arguing that to understand its character one must attend to both its active and passive dimensions. On the active side, experience involves *trying*, a term closely related to *experimenting*. On the passive side, experience entails *undergoing*. When we act upon an object, or when we participate in action together with it, we thereby have an experience of something (Dewey, 1966). In addition, young children's learning does not stem from the mere transmission of abstract concepts; rather, it is deeply rooted in their everyday experiences and sensory explorations. Dewey (1938) emphasized that education should be grounded in the learner's experiential world, and that the meaning of learning arises from the connection between experience and reflection. In the context of early childhood science education, curriculum design should begin with situations familiar to children, such as natural phenomena including water, light, sound, plants, and weather. Through observation, hands-on manipulation, and guided questioning, children are supported in constructing

understanding from their own experiences. An experience-based approach of this kind enhances both motivation for learning and the internalization of knowledge.

2.2 Emphasizing Exploration and Hands-On Constructivist Approaches

This study found that among the science inquiry process skills demonstrated by young children, communication was one of the most prevalent and critical. Transcript analysis showed that children consistently engaged in verbal interactions throughout the entire activity sequence—from exploration and design to evaluation—sharing observations, negotiating ideas, and collaboratively developing their products and problem-solving strategies. Notably, the teacher intentionally scaffolded communication practices in the initial activity, enabling all children to participate in dialogue and cooperative learning. This pedagogical support promoted inclusivity and facilitated the collective construction of scientific understanding (Dilek, Taşdemir, Konca, & Baltacı, 2020). These findings suggest that appropriate teacher guidance not only enhances the quality of children's expression and interaction but also supports scientific reasoning and social development at the group level. From a constructivist perspective, knowledge is not transmitted unidirectionally by teachers but is actively constructed by learners through interaction with their environment and with others. Accordingly, in early childhood science curriculum design, teachers should provide diverse manipulatives and open-ended exploratory contexts that enable children to form concepts through processes of trying, experimenting, and comparing. For example, through activities such as water play, rolling balls, manipulating magnets, or caring for plants, children can gradually observe causal relationships and emerging patterns. Such exploration-oriented curricula not only support conceptual development but also cultivate scientific dispositions, including curiosity, patience, and a spirit of inquiry. Prior research has demonstrated that hands-on, play-based science experiences effectively enhance children's engagement, problem-solving abilities, and foundational scientific thinking (Fleer, 2019; Piaget, 1952; Shih et al., 2025). The present findings align with this literature and further underscore the importance of integrating communication-focused and exploration-based instructional strategies in early childhood science education.

2.3 Curriculum Design for Enhancing Young Children's Thinking Skills

John Dewey emphasized that thinking serves as a tool for individuals to adapt to real-life situations; in other words, humans think in order to live (Mayer, 1950). Dewey further argued that life is in a state of continuous change, such that tomorrow's problems differ from those of today. Consequently, individuals constantly face novel challenges within their daily experiences. Thinking, for Dewey, becomes meaningful only when applied to real-life contexts. For educators, improving teaching and learning methods hinges upon creating conditions that promote rigorous thought, allowing ideas to be tested, refined, and verified. Learning imbued with intellectual engagement is, in essence, thinking itself, and while problems serve as essential stimuli for thought, not all problems elicit reflective thinking. The art of teaching lies largely in calibrating the difficulty of new problems to a level that sufficiently challenges children's cognitive capacities (Dewey, 1966). Dewey also highlighted the importance of cultivating sound thinking habits in students, arguing that thought is a form of experience with educational significance. For students to develop these habits, they must be engaged in authentic experiential contexts—continuous activities that genuinely capture their interest. Within these contexts, problems emerge as the focal point of thinking, aligning with Dewey's problem-solving approach to cognitive development (Mayer, 1950; Tibble, 1966). In the context of early childhood science education, teachers should therefore design curricula that actively foster children's thinking skills. This can be achieved by embedding thought-provoking problems and challenges that stimulate higher-order thinking, thereby promoting deeper understanding of scientific concepts. Moreover, assessment practices should extend beyond paper-and-pencil tests to include strategies that encourage reflective inquiry. By posing essential questions and facilitating problem-solving experiences, teachers can engage children in higher-order cognitive processes during both instruction and evaluation. Through continual exposure to

thoughtfully designed challenges, children's curiosity and intrinsic motivation are enhanced, ultimately supporting their intellectual growth and fostering a lifelong disposition toward inquiry-based learning.

2.4 Integrating Multiple Teaching Strategies in the Design of Science Activities for Young Children

Children should be supported in learning and creating in ways that align with their individual interests and abilities. Empirical research indicates that a range of pedagogical strategies—including direct instruction, child-initiated play, structured learning activities, and interaction with more knowledgeable peers—can effectively promote young children's holistic development; however, no single approach is sufficient for achieving all educational objectives. For instance, social competence tends to develop more readily through play-based experiences than through didactic teaching, whereas direct instruction is often more effective for fostering academic knowledge such as phonemic awareness and number concepts. Accordingly, the design of science activities for young children should employ a flexible and intentional multi-strategy framework that adapts instruction to learners' individual differences, prior experiences, and current levels of understanding in order to address specific and clearly defined curriculum goals (Lin & Shih, 2025; The Education Hub, 2019).

Balakrishnan, B. (2022). Exploring the impact of design thinking tool among design undergrad uates: A study on creative skills and motivation to think creatively. International Journal of Technology & Design Education, 32(3), 1799–1812. https://doi.org/10.1007/s10798-021-09652-y

3. CONCLUSION

Curriculum design in early childhood education extends far beyond the preparation of lesson plans; it functions as a blueprint for children's earliest encounters with learning, relationships, and the world. A high-quality curriculum is therefore a foundational component of effective early childhood education. A central question remains: what does it take to design and implement a curriculum that fosters the learning and development of all children? Drawing on NAEYC's foundational resources and the recent National Academies of Sciences, Engineering, and Medicine (NASEM) report A New Vision for High-Quality Preschool Curriculum, this discussion highlights how early childhood leaders and educators make decisions about what, when, and how children learn in educational settings. As emphasized by both NAEYC and the NASEM report, high-quality curricula must be responsive to each and every child. However, there remains limited empirical and practical guidance on how to design and enact curricula that genuinely address the diverse interests, needs, and strengths of all learners (National Association for the Education of Young Children [NAEYC], 2025; Zeeshan Mehdi, 2025). Within a school-based curriculum framework, early childhood science education should be grounded in children's lived experiences and local contexts, while simultaneously cultivating creativity as a core educational value. Creativity in early science learning is not an optional add-on; rather, it constitutes a fundamental dimension of how young children make sense of the world through exploration, imagination, and meaning-making. Accordingly, teachers should encourage children to actively pose questions (e.g., Why? How? What if?), engage in learning situations that allow for multiple possible answers, and view mistakes as integral to inquiry rather than as failures. This orientation aligns with constructivist and inquiry-based perspectives, which conceptualize learning as a process of hypothesis generation, testing, reflection, and revision. When science activities are designed as open-ended, hands-on, and dialogic experiences, children are more likely to engage in creative thinking, problem posing, and conceptual restructuring. A curriculum that meaningfully integrates science and creativity thus supports not only the development of scientific understanding but also children's curiosity, agency, and confidence as learners. In this sense, creativity functions as both the means and the outcome of early childhood science education, enabling young children to participate in knowledge construction in flexible, imaginative, and socially meaningful ways (Shih & Juan, 2026). Based on this framework, the present study identifies three key principles for early childhood science curriculum design:

(1) experience-based approaches to science learning in early childhood;

(2) an emphasis on exploration and hands-on constructivist practices; and

(3) curriculum design aimed at enhancing young children's thinking skills.

(4) integrating multiple teaching strategies in the design of science activities for young children.

By examining these principles, this study seeks to contribute to the improvement of young children's scientific literacy and to offer practical guidance for early childhood teachers in designing meaningful and developmentally appropriate science learning experiences.

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