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IMPLEMENTING THE SCIENTIFIC APPROACH IN EARLY CHILDHOOD EDUCATION UNDER LOW-RESOURCE CONDITIONS

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Abstract: *The purpose of this study is to describe how the scientific approach is implemented in early childhood education (PAUD) under conditions of limited resources. Its main objectives are to identify early childhood teachers' understanding of the scientific approach, map curricular and classroom management support, and formulate practical strategies appropriate for low-resource contexts. This study employed a qualitative case study design. Data were collected from 10 early childhood education institutions between January and March 2024 through semi-structured interviews, classroom and non-classroom observations, and document analysis. The data were analyzed using Miles and Huberman's interactive model. The findings indicate that, although teachers possess an adequate conceptual understanding of the scientific approach, its implementation is inconsistent. Science activities are conducted without dedicated laboratories and rely on simple materials and the surrounding natural environment, such as school gardens. Teacher-guided questions dominate teaching and learning activities, exhibit limited integration across subject areas, and assessment focuses more on products than on processes. Rigid time structures and budget constraints also constitute major obstacles. Nevertheless, teachers demonstrate creativity by utilizing natural materials and simple digital media. The study concludes that optimizing the scientific approach in early childhood education requires coordinated support, including adequate funding, flexible learning schedules, enriched learning environments, and structured, continuous teacher professional development.*

Keywords: *Early Childhood Education Teachers, Limited Resources, Scientific Approach, Inquiry Development, Early Childhood Education*

A. Introduction

The development of a scientific attitude from an early age plays a strategic role in helping children understand their surroundings and in laying the foundation for reasoning, problem-solving, and responsible decision-making. In the context of globalization and rapid technological advancement, critical, analytical, and communicative abilities have become essential prerequisites for children's success in further education and social life. Accordingly, early childhood education (PAUD) bears a crucial responsibility to provide learning experiences that stimulate curiosity, exploration, and evidence-based reasoning (Kristiana Riatin & Darmiati, 2020).

The scientific approach in education can be understood as a framework that facilitates learning through social interaction and direct experience, aligning with Vygotsky's sociocultural theory, particularly the concept of the Zone of Proximal Development (ZPD). Within the ZPD, Vygotsky emphasizes the importance of adult or teacher support in helping children develop their cognitive abilities. Through the scientific approach, stages such as observing, questioning, experimenting, reasoning, and communicating strengthen social interaction between teachers and students, thereby enhancing their learning processes (Wibowo et al., 2025). Scaffolding, as part of this approach, refers to the support teachers provide to help students understand complex subject matter.

According to Dewey, direct experience is at the core of meaningful education. Dewey argues that education should facilitate an educative experience in which knowledge is acquired not only through direct instruction but also through active engagement and reflection. In this context, the scientific approach provides a framework that enables students to participate actively in the learning process (Chaudhary, 2024a). Thus, the principles of Vygotsky and Dewey are integrated into a learning context that promotes collaboration and interaction between teachers and students.

Furthermore, Piaget's constructivist theory also makes a significant contribution to understanding learning. Piaget emphasizes that children construct their knowledge through experiences and active exploration in their environments. The scientific approach reflects constructivist principles by encouraging students to conduct experiments and investigate the world around them, enabling them to build a deeper understanding through interaction with various concepts (Anida & Eliza, 2020a). This reinforces the idea that effective learning occurs when students are allowed to engage actively in their own learning processes. Accordingly, the scientific approach functions not only as a methodology but also as a robust theoretical foundation within developmental psychology (Chaudhary, 2024b). The theories put forward by Vygotsky, Dewey, and Piaget can be regarded as key pillars underpinning a range of everyday pedagogical practices.

Numerous studies have shown that the effective implementation of the scientific approach can enhance children's engagement, reasoning abilities, creativity, and autonomy in learning (Astini et al., 2019; Marwiyati & Istiningsih, 2020; Ndeot, 2019; Suhendi et al., 2021a). These studies underscore that, when implemented comprehensively, the stages of the scientific approach can support meaningful, child-centred learning. Nevertheless, the implementation of this approach in practice continues to face significant contextual challenges, particularly in settings with limited resources. Constraints related to facilities, large class sizes, limited time, and insufficient professional training hinder the provision of rich and sustainable scientific exploration experiences (Anida & Eliza, 2020b; Kwarteng, 2025).

On the other hand, several studies have identified factors that support and inhibit the implementation of the scientific approach at the institutional and teacher levels (Lobo & Asim, 2018; Ni Nyoman Sriningsih, Ardana, I.K. et al., 2018). However, there remains a scarcity of empirical research providing detailed, process-oriented descriptions of day-to-day practices in early childhood education classrooms facing substantial resource constraints. In other words, few studies have offered a fine-grained account of how the scientific approach is actually enacted in daily practice, ranging from the use of simple media to teachers' strategies for managing time and for process-oriented assessment.

This article seeks to address this gap by providing a more detailed empirical contribution concerning early childhood teachers' practices in implementing the scientific approach in concrete ways amid resource constraints. Unlike previous studies that have tended to emphasize benefits or general principles, this study presents contextual evidence on the strategies, barriers, and everyday practices that reflect the challenges and potential of this approach in the classroom. The novelty of this research lies in its focus on the complex, highly adaptive nature of day-to-day implementation in real-world contexts.

To address this gap, the present study seeks to explore in depth early childhood teachers' understandings and practices in implementing the scientific approach under the resource constraints they encounter. The main focus is to identify the factors that support and hinder the enactment of this approach in real teaching–learning contexts. In addition, this study aims to formulate the adaptive strategies employed by teachers to maintain the meaningfulness of scientific inquiry processes despite working under conditions of considerable limitations in facilities, time, and professional training.

B. Method

This study employed a qualitative case study design to investigate how early childhood education (PAUD) teachers implement the scientific approach under limited-resource conditions and how these constraints are addressed. This design was chosen because it can provide in-depth, contextual insights into the processes, challenges, and strategies implemented (Creswell, 2022).

The participants in this study were 45 early childhood education teachers from ten institutions: PAUD Hamba Maria, TKK Inviolata, TKK St. Fransiskus Asisi Karot, TKK Wejang Asih Mano, TK Sta. Maria Fatima Cewonikit, TK Brando, TKK Bunga Mawar, PAUD Petra, PAUD Sta. Anjela, and PAUD Madre M. Ricci. The institutions were selected non-randomly using purposive sampling, based on specific criteria such as regional representation, variation in institutional status, and the institutions' readiness to participate fully throughout the data collection process. Data were collected over three months (January–March 2024).

Table 1. Brief Profile of Participants

Aspect	Description
Number of teachers	45
Institutions	10 early childhood education (PAUD) institutions
Age range of teachers	25–54 years
Years of teaching experience	3–25 years
Academic qualifications	D2, Bachelor's in ECE (S1 PAUD), Bachelor's in non-ECE fields (S1 non-PAUD)

Three techniques were employed in this study: (1) semi-structured interviews with teachers to explore their experiences, challenges, and strategies; (2) non-participant observations inside and outside the classroom to examine the implementation of the scientific approach, teacher–child interactions, and the use of learning resources; and (3) document analysis of the curriculum, lesson plans (RPP), and teaching materials to trace the integration of the scientific approach in instructional documents.

The data were analyzed using the interactive model of Creswell & Creswell (2022), which includes data condensation, data display, and the iterative drawing and verification of conclusions. The coding process began with open reading and the drafting of analytic memos based on interview transcripts and observation notes. Initial codes that emerged included: use of natural materials, time constraints, teacher-guided questioning, and product-based assessment. These initial codes were then grouped into major themes, namely: Structural Constraints, Pedagogical Practices, and Adaptive Strategies. An example of an initial code, such as the use of natural materials, was later developed into a subtheme within the broader theme of strategies for utilizing local resources.

To support the document analysis, the following review procedure was applied: identification of relevant institutional documents; application of inclusion criteria (related to early childhood education, explicitly mentioning the scientific approach, and valid during the study period); screening and extraction of information (learning objectives, activities, assessment, schedules/resources); and critical appraisal of the alignment of these documents with inquiry-based learning standards.

Source and methodological triangulation were used to strengthen data validity. Findings from interviews were compared with those from observations and document analysis. Limited member checking was also conducted to confirm preliminary findings with several participants.

C. Result and Discussion

This study reveals three main findings. First, the scientific approach is implemented only partially, with classroom practices dominated by teacher demonstrations and limited engagement with the full inquiry cycle. Second, although teachers rely on local resources and demonstrate creativity, they continue to face challenges in process-based planning and in documenting and interpreting children's learning processes. Third, a noticeable gap exists between teachers' conceptual understanding of the scientific approach and its practical classroom implementation, a gap further exacerbated by constraints related to time, facilities, and professional training.

The first finding shows that most teachers understand the stages of the scientific approach. Still, its implementation is confined mainly to the initial stages (observing and experimenting), without systematic continuation to the stages of reasoning and communicating. This is consistent with the findings of Marwiyati and Istiningsih (2020), which indicate that teachers often stop at demonstrative activities and do not yet guide children to construct arguments based on their observations. A teacher from PAUD Petra stated, "We know that the stages of the scientific approach are important, but sometimes there is not enough time to repeat or compare results, especially when there are many children and all of them are active." This statement underscores that time constraints and rigid schedule structures hinder the realization of a full inquiry cycle.

Second, teachers' creativity in utilizing natural materials such as leaves, stones, and rainwater demonstrates the potential of context-based local pedagogy, as supported by Ishak et al. (2020). However, in the absence of adequate professional training, these strategies have not yet yielded well-documented scientific evidence. A teacher from TKK Bunga Mawar explained, "We use leaves, stones, and rainwater for experiments. The children enjoy it, but we are not yet able to record the process systematically because we are not used to it." This indicates that although the use of the environment supports constructivist principles (Piaget), without strong scaffolding structures (Vygotsky), learning experiences do not reach a deeper reflective level.

Third, there is a gap between teachers' knowledge and practice in developing open-ended questions and assessing children's thinking processes. Most questions are teacher-directed rather than generated by children, thereby reducing the potential for active constructivism in the classroom. A teacher from TKK Inviolata remarked, "We are used to asking questions so that activities stay on track, but sometimes this ends up providing less opportunity for children to ask their own questions." There is an urgent need for teacher training that not only conveys the concepts of the scientific approach but also facilitates the practical enactment of inquiry-based facilitation (Wulandari et al., 2019; Zukmadini et al., 2021). These findings clarify the knowing–doing gap, which can only be bridged through contextual and reflective training.

Time constraints also constitute a significant barrier to the development of scientific practices. Limited instructional time (3–4 hours per day) leaves little room for repeated exploratory activities. As stated by a teacher from PAUD Sta. Anjela, "There is no specific time for experiments. If we do them, it is usually in a hurry so as not to disrupt other scheduled activities." This finding supports the literature indicating that scientific practice requires flexible time and space for repetition to enable children to construct knowledge through distributed experiences (Silitonga & Tangkin, 2023; Suhendi et al., 2021b).

In response to these challenges, this study proposes the Lean Inquiry Cycle (LIC) as a practical and contextual solution. LIC compresses the scientific cycle into structured micro-cycles that can be implemented under constrained conditions. The stages of LIC include:

Stage	Main Activities
Observe	Observing phenomena using local materials (leaves, water, soil, etc.)
Question	Generating open-ended questions (from children and teachers)

Test	Conducting simple experiments using recycled tools/materials
Record & Represent	Recording results through drawings, simple graphs, or stories
Share & Reflect	Sharing results with peers and teachers; oral or visual reflection

This model is grounded in the principles of distributed practice and scaffolded inquiry (Vygotsky) and supports active engagement and the representation of experience (Matusov, 2011; Muhiddin et al., 2024). The LIC directly responds to time, media, and structural constraints by providing a routine framework that can be adapted and replicated across diverse early childhood education (PAUD) contexts.

Theoretically, the findings of this study enrich the understanding of Vygotsky's sociocultural theory. The scaffolding process that ideally occurs within the Zone of Proximal Development is, in practice, disrupted by rigid systems and structures. The LIC offers a practical framework to revitalize this scaffolding through flexible micro-stages. In addition, these findings reinforce Piaget's constructivist principles and Dewey's theory of experiential learning, in which direct engagement and reflective cycles are key to meaningful learning.

Thus, this study not only addresses the empirical gap identified in previous literature but also contributes an implementable model that is both theoretically and practically relevant to scientific-approach-based early childhood education in contexts of limited resources.

D. Conclusion

This study shows that the scientific approach in early childhood education (PAUD) learning within low-resource contexts is often implemented only partially, primarily due to structural barriers such as limited time, materials, and teacher training. Although teachers possess adequate conceptual understanding, classroom practices do not always reflect the full inquiry cycle. These findings motivate the development of the Lean Inquiry Cycle (LIC) as an adaptive solution that enables teachers to implement the stages of the scientific approach within realistic, contextually grounded micro-cycles.

In practice, this study offers guidance for teachers, principals, and curriculum designers in planning flexible, affordable, inquiry-based activities. From a policy perspective, the results underscore the importance of government support in the form of regular funding, more flexible scheduling, and ongoing teacher training focused on facilitating inquiry.

The limitations of this study lie in its scope, which is confined to a single region and a relatively small number of participants, so that generalization of the findings should be made with caution. In addition, the qualitative design provides depth of analysis but does not capture the population's breadth. For future research, it is recommended to conduct action research to implement and evaluate the effectiveness of the LIC model, as well as quasi-experimental studies to compare learning outcomes between classes implementing LIC and those using conventional methods.

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