Examining Implementation Challenges in Preschool Science Education through an Activity Case

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*Abstract: The core value of preschool science education lies in stimulating children's interest in inquiry, developing their inquiry abilities, and fostering a scientific attitude, ultimately helping them develop scientific cognitive methods and thinking habits. Taking the science activity "Bai Shi Pagoda" in a kindergarten senior class as a case study, this paper analyzes the implementation challenges in preschool science education from three aspects: activity objectives, content, and methodology. It identifies issues such as activity objectives focusing on superficial knowledge and skills, content overemphasizing the transmission of disciplinary concepts, and methodologies leaning towards conclusive receptive learning. Based on cognitive development theory, intrinsic motivation theory, situated cognition and learning theory, and the requirements of the *Guidelines for the Learning and Development of Children Aged 3-6*, this paper explores how to return to the essence of preschool science education and promote the holistic cultivation of children's scientific literacy, thereby providing empirical support for enhancing the high-quality development of preschool science education.*

Keywords: Preschool Science Education; Scientific Literacy; Life-Oriented Approach; Discovery Learning

Introduction

The essence of preschool science education is "a child-centered process, guided by teachers, through which children actively explore the surrounding world and construct scientific understanding"[1]. Unlike the traditional "knowledge indoctrination" approach in science education, modern preschool science education, guided by the Kindergarten Education Guidance Outline (Trial) and the *Guidelines for the Learning and Development of Children Aged 3-6* (hereinafter referred to as the Outline and the Guidelines), emphasizes a tripartite value orientation focused on "stimulating inquiry interest, developing inquiry ability, and cultivating a scientific attitude"[2]. However, in actual teaching practice, the essential value of science education is often diluted, with numerous practical problems existing that run counter to these foundational concepts.

1. Presentation of a Kindergarten Science Education Activity Case

This study selected the kindergarten senior class science activity "White Stone Pagoda." The activity objectives were defined as follows: enabling children to build structures by changing the shape of paper to increase the support area; exploring methods for stacking waste paper to achieve height through cooperation; and fostering a willingness to share successful methods and experiences of failure encountered during the building process. The activity record, compiled based on original observation notes, is presented below:

1.1 Activity Introduction Phase

The teacher initiated the activity using the tongue twister "Bai Shi Ta" (White Stone Pagoda):

"White stone pagoda, white stones stacked, white stones stack the white pagoda, the white pagoda is built with white stones, the white stone pagoda built stands white and grand."

The teacher then asked, "What is the white stone pagoda built with?" After the children responded with "stones," the teacher played an audio clip featuring a discarded paper character expressing

dejection, and followed up by asking, "Whose voice is this? How does it make you feel?" Upon hearing the children's answers of "angry" and "sad," a multimedia presentation was played where the discarded paper character said, "It's me! I am a piece of used paper. They threw me aside and don't want me anymore!" Utilizing this character to capture interest and evoke emotional resonance from the children, the teacher guided them with further questions: "What is it?" "What is used paper also called?" "What can we do with waste paper?" After the children answered "recycle," the teacher prompted further: "What other uses does it have? Would you like to cheer it up and play a game with it?" The children responded with "yes," concluding the introduction phase.

1.2 Core Operational Phase

Inquiry Activity One: Making the Paper Stand Up

The teacher presented the game rules and guided the children to read them aloud together: "Each person gets one piece of paper. Without using any tools, make the paper stand up. Be careful while handling it, and make sure the paper doesn't cut your little hands." After emphasizing the safety precautions, the teacher distributed the paper and asked the children to attempt the task. Once some children had succeeded, the teacher asked, "Who can tell us how you made the paper stand up?" The children responded with answers like "fold it gently" and "roll it up." The teacher did not pursue further questioning.

Inquiry Activity Two: Building a Paper Tower

The teacher played a video where the discarded paper character said, "You children are amazing! It feels so good to stand up. I wish I could be built tall like the White Stone Pagoda, but unfortunately, I'm not as hard as stone. Can you help me?" This guided the children to understand the task of building a paper tower. By displaying pictures of towers such as the Leaning Tower of Pisa, the Eiffel Tower, and Leifeng Pagoda, the teacher explained the structure of a tower: "The very top is the finial (or spire), which is always pointed; the middle is the tower body, like our own bodies; and the bottom is the tower base, like the foundation of a house, which must be solid." While the children worked in groups to build their towers, the teacher circulated to provide guidance. When children asked questions or encountered difficulties, the teacher's responses primarily consisted of statements like "The base needs to be stable" and "It must be supported to be built high," without offering further support to extend their inquiry.

1.3 Communication and Discussion Phase

The teacher invited children from each group to introduce the name and design of their work (specific interactions are detailed in Table 1).

Table 1 Teacher Guiding Children to Introduce Their Group-Named Towers

Group	Teacher's Question	Children's Responses
1	What is the top of your "Su-feier Tower" used for?	Enjoying the view from the top.
	People can stand on top, and it's like an observation deck for enjoying the scenery outside. Is there anything else?	There's a small door down here to see the statue inside.
2	What does the "Radar Tower" have?	The first floor has statues, and there are also some photos. The second floor is for eating.
	Is there anything else?	Next to the restaurant, there are mountains that can be sold or moved.
	What are these two used for, do you know?	These two are for lightning protection.
3	"Lei'ao Tower," who would like to introduce it?	There's a statue here.
	Whose statue is that?	Lei'ao/Ultraman.

Teacher's Question: "What problems did you encounter while building?" The children responded, "It kept falling over," and "The wind would blow it down." The teacher then guided, "How did you solve it?" The children answered, "Prop it up," and "Handle it gently." The teacher added, "Each layer needs to have a flat surface to build upwards," without delving into a deeper analysis that the core factors affecting the tower's structural stability are supporting force and balance.

1.4 Activity Conclusion Phase

The teacher played a video where the discarded paper character said, "Seeing your paper towers has truly amazed me. I really enjoyed playing the game with all of you. If you come up with new ideas, remember to call for me." The teacher then summarized: "The children's ideas are truly wonderful. Discarded paper can be used not only to build paper towers but also for many other purposes, which await your continued discovery." The activity concluded at this point.

2. Implementation Challenges in Preschool Science Education Viewed through the Case Study

Preschool children's thinking is characterized by concreteness, imagery, and egocentricity. The perplexities they encounter in daily life represent 'authentic problems' worthy of children's inquiry, capable of stimulating their intrinsic curiosity and desire for knowledge. However, in the "White Stone Pagoda" activity, the practical logic of science education contradicted the learning patterns of young children. Analyzed through the lenses of cognitive development theory, intrinsic motivation theory, and situated cognition and learning theory, this case reveals the following three dilemmas:

2.1 The Singularity of the Goal Dimension, Fragmenting the Holistic Composition of Scientific Literacy

Scientific literacy is a multidimensional and comprehensive set of competencies, encompassing four core dimensions: scientific knowledge, inquiry-based thinking and methods, scientific spirit and attitude, and the interrelationship between science, technology, and society[3]. Although the case objectives included "increasing the support area by changing the shape of paper," "exploring methods to stack waste paper high," and "sharing experiences of success and failure," they were confined to surface-level goals of operational skills and verbal expression. They did not involve the cultivation of scientific inquiry thinking or scientific spirit, nor did they connect the value of science and technology to social life, thereby failing to integrate the four dimensions of scientific literacy. Foundational knowledge-such as changing an object's shape can enhance its supportive force, the width of a tower's base relates to structural stability, and the position of the center of gravity affects balance-is essential for children to understand scientific phenomena and engage in scientific inquiry. As the teacher did not clearly convey these concepts, the children's exploration lacked purpose, devolving into mechanical operation-knowing how without understanding why.

2.2 Content Focuses on Transmitting Disciplinary Concepts, Overlooking Lived Experience and Interest

The hierarchical transmission of concepts essentially follows the internal logic of disciplinary knowledge. Teachers, by constructing a stepped content system, help learners gradually deepen their understanding of core disciplinary concepts[4]. In the case activity, the transmission of disciplinary concepts did not form a systematic hierarchical progression. Children's understanding of "structural stability" presupposes foundational concepts such as supporting force and center of gravity. In turn, understanding supporting force requires sufficient sensory perception that the size and shape of the contact area affect the tower's stability. Sensory experience is key to conceptual understanding. However, during the activity, the children did not connect the sensory experience of "folded paper can stand up" with the conceptual understanding that "supporting force is the paper's ability to hold up the paper above without collapsing." This required the teacher to provide "scaffolding" to guide the children in operating, comparing, and reflecting on how to change the paper's shape to increase its load-bearing capacity. Yet, in the activity, the children remained at the level of superficial trial-and-error, repeatedly folding, rolling, and stacking paper, merely gaining surface-level experience like "folding it this way works." Even though the teacher presented the task of "building a tower with waste paper," it was difficult for the children to arrive at the inquiry-based conclusion that three-dimensional structures provide greater supporting force, let alone generalize the core concept that

a wider tower base and a lower center of gravity lead to greater stability. The purpose of young children's science learning is to solve problems in daily life. However, at the end of the activity, the teacher vaguely stated that "waste paper has many other uses," failing to connect the core concept of structural stability to the children's lived experience.

2.3 Methods Lean Towards Conclusive Receptive Learning, Lacking Systematic Guidance

Young children's scientific inquiry should follow a complete logical cycle: raising questions, making conjectures and hypotheses, testing and reasoning, analyzing and summarizing, and transferring and applying knowledge[5]. However, the case activity lacked the teacher's "scaffolding" to support the children's inquiry and building process, resulting in superficial, procedural operations.

First, the introduction phase is a crucial step for activating children's prior experience, creating cognitive conflict, and generating inquiry questions[6]. The teacher awkwardly linked stones and waste paper through the building action described in the tongue twister, without guiding the children to perceive the differences in material and supporting force between the two. Although the discarded paper character evoked emotional resonance in the children, their focus was on cheering up the paper. Their engagement with the scientific problem of "how can waste paper possess supporting force" remained at an emotional level, failing to generate genuine inquiry motivation.

Second, the operational phase should center on "conjecture first, then test; use testing to verify conjecture"[7]. The teacher did not guide the children to think before operating, such as by asking "what kind of folding method can make the paper stand up?" or "will a wider or narrower tower base be more stable?". This led to blind experimentation, preventing the children from establishing the core logic that a wider base and a lower center of gravity contribute to greater stability. When encountering authentic, inquiry-worthy problems like the tower being unstable or not reaching sufficient height, the teacher's responses, such as "prop it up" or "the base needs to be stable," were overly general. The children understood what to do but not why.

Third, the discussion phase is key for organizing experience and extracting patterns[8]. Although the teacher designed a session for children to share their building methods and experiences of success and failure, the teacher's questions revolved around the tower's functions. Feedback remained at a superficial level, like "great job," and failed to inspire further reflection on the tower's structural stability.

Finally, a complete science activity should progress in layers around a core inquiry question[9]. Although the teacher set the tower-building task and conducted two operational activities, the intrinsic connection between the two operations was not fully explored. The activity concluded with the question, "What other uses does waste paper have?", without extending the core concept to daily life or other activity areas. The inquiry experience remained confined to the activity itself, failing to form a complete chain of perception, understanding, and application.

3. Countermeasures for the Implementation Challenges in Preschool Science Education

Young children's scientific learning occurs through the exploration of concrete objects and the resolution of practical problems. In this process, they attempt to discover similarities, differences, and connections between things, acquire rich sensory experience, fully develop imaginal thinking, and gradually cultivate logical thinking abilities. The case activity consistently failed to establish a systematic inquiry scaffolding for the children. Consequently, their operational experience remained superficial and formalized, failing to genuinely engage deeper-level thinking. Based on the aforementioned dilemmas, countermeasures are proposed from the following five aspects to return to the essence of preschool science education and promote the holistic cultivation of scientific literacy.

3.1 Reconstructing Science Education Goals to Anchor the Core of Cultivating Scientific Literacy

The core objective of preschool science education is to lay the foundation for the scientific literacy of the entire populace, serving the long-term strategy of building an innovative nation. Scientific literacy is a multidimensional and comprehensive set of competencies. It extends far beyond merely memorizing scientific knowledge and facts; it is fundamentally a core mode of thinking for understanding the world, processing information, and engaging in public affairs. Consequently, cultivating a scientific attitude and spirit should become the primary goal of preschool science

education activities. However, science education has gradually shifted to another extreme-overemphasizing children's interest in and experience of science to the point where many science activities are strong in child-friendliness but weak in scientific rigor. They often lack both the progressive development of children's scientific experience and a systematic, in-depth cultivation of their scientific inquiry abilities. In the case study, the children were interested in the game of "making the paper stand up," but the scientific knowledge gained through "play" consisted mainly of fragmented factual information. The teacher also paid little attention to the children's understanding of core scientific concepts[10], blurring the boundaries and defining attributes of the science activity. Therefore, science education goals should not solely emphasize cultivating scientific interest, emotion, inquiry desire, and ability in a formalistic sense. They must simultaneously strengthen the scientific attributes and contemporary relevance of the activities to nurture children's imagination for the future. Using life and play as fundamental means, these goals should support the coordinated development of children's scientific interest, inquiry abilities, scientific experience, and scientific thinking.

3.2 Optimizing Science Education Content to Implement a Child Life-Oriented Science Approach

The value of a life-oriented science approach lies in adhering to children's cognitive development patterns, stimulating intrinsic learning motivation, and establishing connections between science and daily life[11]. Placing children at the center has become a fundamental principle for preschool teachers in organizing curriculum content and selecting educational methods[12]. Guided by this philosophy, science education should be rooted in children's daily lives. The questions they encounter in life spark their desire to explore and drive them to seek answers. This transforms children's life experiences into investigable scientific questions, allowing them to perceive scientific principles through concrete experience and achieve a transition from observing phenomena to exploring underlying principles. In the case study, the teacher should have used life experience as the starting point for inquiry. Beginning with the children's familiar experience of "building blocks," the teacher could guide them to transform this life experience into investigable questions such as: "When we build with blocks, towers with wide bases don't fall easily. Can waste paper towers be built the same way?" and "Why can paper stand up after being folded?" During operations, children could compare the supporting force of flat paper versus folded paper, the stability of towers with wide bases versus narrow bases, and the load-bearing capacity of paper folded into different shapes. This would help them understand scientific principles: three-dimensional structures provide greater supporting force; a lower center of gravity increases stability; and a larger contact area enhances stability. To strengthen the scientific focus of extended tasks, life-oriented assignments such as "using waste paper to make stable storage racks" or "finding structurally stable items at home" should be designed, allowing children to consolidate their understanding of scientific principles through problem-solving.

3.3 Innovating Science Education Methods to Empower Experiential Discovery Learning

The essence of young children's science learning is inquiry-driven experiential learning, whose core value lies in the interest in inquiry, the process of inquiry, and personalized discoveries from inquiry. Due to variations in children's cognitive levels, teachers in practical teaching should allow for the existence of answers at different levels and avoid pre-establishing standardized, uniform conclusions for children's inquiries. As long as children, through independent exploration, discussion, operation, and summarization, can articulate their reflections after inquiry, it constitutes effective inquiry. Teachers need to provide scaffolding for children, such as helping them use drawings or symbols to record the steps and results of their inquiry, and guiding them to propose explanations for problems during communication and discussion to eventually solve them. It is within such inquiry processes that children's scientific literacy-including observation skills, problem-solving abilities, preliminary logical thinking, communication skills, and perseverance-gradually takes shape. Therefore, teachers should innovate science education methods, encouraging children to gain discoveries of their own, which may be naive or even partially incorrect, through practical operation and reflection. The sense of accomplishment and joy derived from such firsthand, experience-based discoveries serves as a powerful motivator for sustaining children's ongoing engagement in scientific inquiry.

3.4 Innovating Science Education Models: Establishing Interdisciplinary Project-Based Learning Pathways

Project-based learning is primarily oriented towards solving real-life problems, integrating isolated disciplinary content such as science, technology, engineering, mathematics, and art around a central

project. This represents a current innovation in preschool science education models. Project activities follow a pathway characterized by being child-led, problem-driven, inquiry-sustained, and integration-focused. They guide children through sustained inquiry, observation and creation, field investigations, presentation of outcomes, and reflection, fully leveraging children's agency. These problems are challenging for young children, stimulating continuous engagement, thinking, and problem-solving, thereby more effectively fostering deep learning and further cultivating their higher-order thinking skills. The case activity could also be redesigned as a project-based learning task. Using the driving question, "How can we build a tower with a stable structure using waste paper?", children would be guided to solve the problem through operation, discussion, and reflection. Teachers would encourage children to make autonomous decisions and engage in cooperative inquiry, cultivating their problem-solving abilities and sense of collaboration.

3.5 Upholding the Essence of Science Education to Construct a New Human-Machine Symbiosis Ecosystem

The era of AI intelligence offers resources and feedback for more precise personalized learning pathways. The experiences of personalized, immersive, and visual learning allow young children to view scenes of the micro-world and macro-cosmos, breaking through the limitations of time, space, and physics. More intuitive data recording enables visual analysis, presenting opportunities for science education in this AI-driven age. Simultaneously, children's science learning faces new challenges, such as the risk of superficial cognition and the gradual weakening of authentic, hands-on experience. This compels us to reconsider the value and role of teachers in preschool science education. Regardless of technological advancements, the genuine experiences, active inquiry, deep thinking, and emotional connections of children, along with the professional judgment and humanistic care of teachers, remain irreplaceable by AI. Therefore, we must steadfastly uphold the essence of science education. While proactively embracing technological transformation, we must enhance our own competencies and application skills to construct a new educational ecosystem of human-machine symbiosis. This will enable children to engage in active inquiry within an environment interwoven with the real and the virtual, truly empowering their scientific exploration and holistic development.

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