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PRESCHOOLER'S SCIENTIFIC CREATIVITY: A RESEARCH APPROACH NEEDED IN EARLY CHILDHOOD EDUCATION

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Abstract. In recent years, the issue of developing preschoolers' scientific creativity has been a concern from both theoretical and practical aspects. However, with the limited number of studies, it can be affirmed that this is a new research topic in early childhood education. This study used the document analysis method to explore the concept, nature, structure, and characteristics of preschool children's scientific creativity, ways to foster preschool children's scientific creativity, as well as introduce three scientific creativity assessment tools. On that basis, several research orientations on preschoolers' scientific creativity in the context of Vietnam have been proposed.

Keywords: creativity, science, scientific creativity, preschoolers, early childhood education.

1. Introduction

According to the 2019 report on the Future of Education and Skills 2030 by the Organization for Economic Cooperation and Development [1-2], creativity is crucial in generating novel value and tackling complex challenges. It is also increasingly essential in promoting sustainable development. Consequently, nurturing learners' creative capacity is one of the fundamental objectives of education for personal and social growth in the future. Creativity is often domain-specific and highlights the significance of knowledge within particular fields as a crucial determinant of creativity. Several studies have suggested that it is both necessary and feasible to foster scientific creativity in young children from an early age, including those in early childhood education. This view aligns with the current cross-cutting perspective of the Vietnamese Early Childhood Education framework curriculum, which underscores the need for innovative educational settings to encourage and facilitate children's active exploration, experimentation, and creativity enjoyably and engagingly [3].

Preschool children have a strong need for exploration and hands-on experience with scientific situations in real life. Children's creative thinking skills have been clearly demonstrated through their various activities and plays [4]. Therefore, preparing cognitive foundations, including the ability for scientific creativity, is crucial in helping children proactively and creatively adapt to learning activities in primary school and succeed in the future. To date, research on the scientific creativity of preschool children has been carried out in several countries, including Malaysia, the United Kingdom, China, and Turkey. Some related issues, such as the structure and assessment scale of the scientific creativity of children, have been preliminarily explored. However, the number of publications on this topic is still minimal and focuses only on a few authors [5].

In Vietnam, the issue of developing scientific creativity for children has not been addressed

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in research at most educational levels, including early childhood education. This study emphasizes that scientific creativity in preschool age is an interesting topic that needs more attention in early childhood education research in Vietnam. Based on exploring the concept, nature, and characteristics of scientific creativity in children, the authors propose several research directions to support the development of scientific creativity in preschool children.

2. Content

2.1. Research method

This study employs a method of document analysis and synthesis. The research materials include scientific articles, books, and English and Chinese theses related to the topic of scientific creativity in children. The documents were searched using "Google Scholar," "ResearchGate," and other search engines. The specific search keywords for the documents are as follows:

Table 1. Keywords for literature search

English	Chinese
"Scientific creativity" OR "Creativity in science" OR "Science creativity" AND "Kindergarteners" OR "Preschoolers" OR "Young children" OR "Preschool children"	"科学创造力" 或 "科学创造性" 或"科学创新" 和 "幼儿园小孩" 或 "学龄前儿童" 或 "学前儿童" 或"幼儿，幼童，小孩子"

After searching for the documents, we proceeded to skim the titles, keywords, and abstracts to select and categorize them according to their content. Then, the documents were read, analyzed, and synthesized for relevant content to complete the draft.

2.2. Research results

2.2.1. Scientific Creativity in preschool children

Creativity refers to the ability to establish novel relationships between events and phenomena and to generate fresh experiences, ideas, and products within the context of new thinking. Fox and Schirrmacher (2014) view creativity as an attitude, process, and skill that involves a unique perspective on the world where only possibilities exist rather than right or wrong answers [6]. Torrance (1962) believes that creativity involves a sensitive process of identifying problems, knowledge gaps or inconsistencies, seeking solutions, making predictions, developing hypotheses, testing them, and presenting results [7]. Therefore, the key differences between highly creative and less creative individuals are self-awareness, awareness of others, courage, determination, emotions, sensitivity, curiosity, openness to external stimuli, and receptiveness to the ideas of others. The four key aspects of creative thinking skills include fluency, originality, elaboration, and flexibility [8-9]. Fluency involves generating numerous diverse thoughts about a given problem; originality entails developing thoughts that are unlike any other and thereby making them unique; elaboration involves expanding on an idea by making it more detailed, interesting, or complex; and flexibility entails the ability to change the direction of thinking or to think differently.

In essence, scientific creativity refers to a specific type of creativity in which individuals blend their scientific knowledge with their creative abilities to achieve a scientific vision [10-15]. Ayas and Sak (2014) suggested that scientific creativity is the outcome of converging several cognitive and non-cognitive variables, including intelligence, creativity-related skills, scientific skills, personality traits and motivations, interests, focus, knowledge-seeking, and the permutation of opportunities in psychological factors [13]. It can be regarded that scientific creativity is a creative problem-solving process comprising three stages: (1) hypothesis generation, (2) experimental design and implementation, and (3) evidence evaluation. While non-cognitive factors impact scientific creativity, they do not constitute the structure of scientific creativity [11].

In terms of the structure of scientific creativity in preschool children, Chin and Siew (2015) suggested that the ability to be scientifically creative can be reflected in three main components, including [16]: (1) Product: scientific knowledge, phenomena, and problems; (2) Process: imagination and thinking; (3) Trait: flexibility, originality, elaboration, the abstractness of titles, and resistance to premature closure.

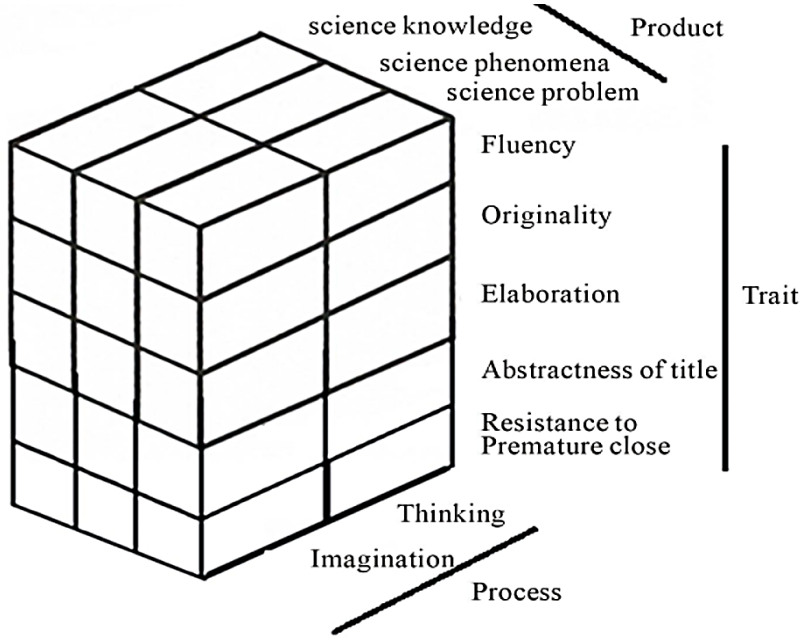

Figure 1. The model of preschoolers' scientific creativity structure [13]

Meanwhile, even though evaluating the scientific creativity of children is still emphasized through components such as flexibility, fluency, and originality, Atesgoz and Sak (2021) divide scientific creativity into two component skills, namely: (1) Proposing scientific hypotheses and (2) Designing scientific experiments. [17]

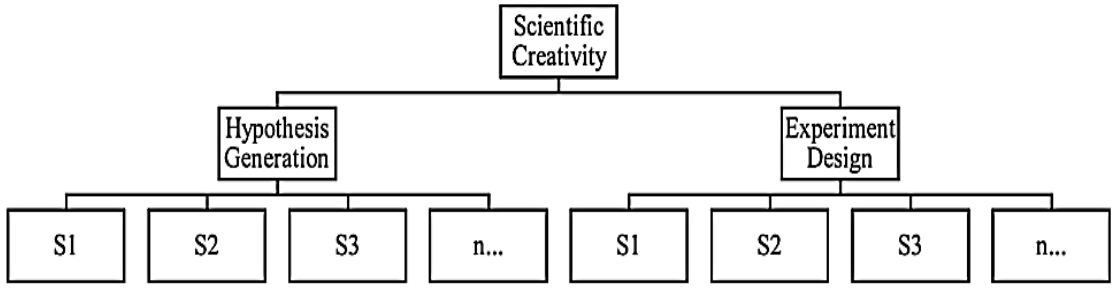

Figure 2. The theoretical framework of scientific creativity [17]

The most important characteristic of scientific creativity is the ability to generate a large number of hypotheses for a specific problem or situation. An important criterion for scientific creativity is to think and act like scientists. However, this skill is not only reserved for scientists but can also be developed for children from an early age through innovative educational activities [14-15]. The scientific creativity of children is enhanced when they participate in activities that allow them to use scientific processes and exploration skills [18]. Such scientific activities model how scientists work and conduct research and can encourage children to use various scientific skills, thereby generating creative ideas and developing their scientific creativity [19]. In addition, limited scientific knowledge can lead to poor scientific creativity [20-21]. Therefore, teaching

programs and scientific activities need to be carefully planned to encourage scientific creativity [21].

The findings of Ya-Ling Hou's (2009) study indicate that family environmental factors positively impact children's scientific creativity, including their originality, flexibility, adaptability, sensitivity, and collaboration [22]. Moreover, the study provides evidence that attitudes toward science influence children's scientific creativity. In addition, although the birth month was not correlated with scientific creativity, the study revealed that boys outperformed girls in the dimensions of originality, fluency, and flexibility.

2.2.2. Measurement Tools for assessing scientific creativity in preschool children

Currently, there are a variety of measurement tools available to assess scientific creativity in preschool children, which have been employed in research studies. One extensively utilized scale was developed by Ya-Ling Hou (2009) [22] and is frequently employed in studies conducted in China. This scale emphasizes providing hands-on activities to children and evaluates their performance accordingly. Conversely, the FSCT tool, developed by authors from Malaysia, focuses on drawing tasks for children [16] [23]. Another measurement tool, developed by authors from Turkey, involves the use of animations in tablet applications with children providing answers through verbal interaction with the researcher [17]. Specifically:

❖ ***The measurement tool for scientific creativity by Ya-Ling Hou***

Ya-Ling Hou (2009, 2013) proposed a tool to measure scientific creativity in children that involves hands-on problem-solving activities rather than drawing. The tool comprises five practical exercises, namely Blowgun, Air gun, Paper cup fan, Person on a string, and Dancing peas. These activities utilize commonly available materials such as straws, grass, bamboo, potatoes, toothpicks, clay, boxes, aluminum foil, and film to encourage children to "play with science" and develop their learning and creativity. Researchers collected samples of children's behaviour during the practical activities, classified and arranged them, and continuously evaluated them based on fluency, flexibility, originality, sensitivity, and effective collaboration criteria. Each criterion was assessed on a scale of 0, 1, and 2. The significance of the five types of behaviours in this study is explained as follows [16] [24]:

Firstly, fluency represents the number of ideas and ways to complete tasks quickly during the process. Secondly, flexibility refers to finding alternative ways to practice rather than sticking to one idea. Thirdly, originality represents the uniqueness of the response that provides perspectives that other children have not thought of or are reasonable ways different from those of other children. Fourthly, sensitivity refers to being aware of problems and quickly discovering the "key" to the issue. Finally, effective collaboration highlights how children pay attention to the needs of others, support, share ideas, and practice with their peers during discussions or activities.

❖ ***Figural Scientific Creativity Test (FSCT):***

FSCT is considered the first test specifically designed for measuring the scientific creativity of preschool children, as published in an international journal [17]. A group of authors from Malaysia developed this test to evaluate the creative qualities of science in 5-6-year-old preschool children [16]. The system consists of two independent and equivalent FSCT tests designed to measure pre-test and post-test. Each test includes six categories constructed based on the Science Creativity Structure Model proposed by Hu and Adey (2002) [11] and scored using criteria adjusted from Torrance and colleagues' research (2008). The categories were developed through three main factors, including (1) product (scientific knowledge, scientific phenomena, and scientific problems), (2) process (imagination and thinking), and (3) trait (flexibility, originality, elaboration, abstractness of titles, and resistance to premature closure).

The FSCT test comprises six open situations: (1) sinking a plastic lid in water, (2) finding non-magnetic objects, (3) drying orange juice on the floor, (4) how a shadow is formed, (5) materials that do not dissolve in water, and (6) separating sand from a salt and sand mixture. The test items in the scale require primarily visual answers. When instructed to label or name the

pictures they drew, the children are asked to write a small amount of text. The evaluation tasks were designed to manage individuals in small groups of 5-10 children. Each category requires ten minutes to complete, and the actual drawing time is 60 minutes. The evaluation requirements in this test are similar to those in other test periods. The evaluator must not only try to make the child feel comfortable but also strive to complete the evaluation tasks. While performing the evaluation tasks, the teacher must guide the children to stimulate all aspects of scientific creativity. Torrance and colleagues (2008) suggest that the instructor can help preschool children who cannot write their own titles or labels in the creativity assessment task. Therefore, the instructors in this study briefly interviewed each child to obtain the title or label and recorded it on the response sheet to achieve more reliable scores for the pictures.

The authors have published a test in three academic articles. The first article aimed to demonstrate the reliability and validity of the measurement tool after administering it to a sample of 30 children [16]. Subsequently, the authors employed this measurement tool in a study involving 144 preschool children aged six [25]. In the third article, the authors re-evaluated the reliability and validity of the measurement tool through Rasch model analysis [23]. Despite certain limitations, including the need for children to write and draw, as well as the protracted assessment period, which might impinge on children's concentration, this measurement tool presents high reliability when assessing young children's scientific creativity [16-17] [23]. Moreover, the authors identified the limitations of the measurement tool and provided valuable recommendations for future studies that adopt this assessment tool.

❖ ***Test of scientific creativity animations (TOSCAC)***

TOSCAC is an animation-based assessment of scientific creativity designed for use with preschoolers through second-grade students. It was developed by Atesgoz and Sak (2021) [17] and tested on a sample of 801 children, including 221 preschoolers aged 4-6, 278 first-graders, and 302 second-graders. The tool is software-integrated and features Turkish-language voiceovers for instructions. The creation of hypotheses and the design of experiments to explore scientific discovery in the form of the dual search were used as components of TOSCAC, with flexibility, openness, and uniqueness used as the criteria for these components. Each component includes three sub-tests, each comprising an open-ended ending item.

- *The scientific hypothesis-generating consists of three tasks:*

(1) The first task measures the effectiveness, feasibility, and uniqueness of hypotheses in the hypothetical space in the field of biology. This task involves an animated scenario in which a child walks past a swamp. A sudden question arises in the child's mind about the lives of those in the swamp. Children are asked to generate multiple ideas (hypotheses) related to the question.

(2) The second task, themed around "Water," measures the effectiveness, feasibility, and uniqueness of hypotheses in the hypothetical space in the field of chemistry. In the animated film, two children are drinking water from their water bottles after they become tired. They realize that the water in the two bottles has different temperatures. Students are asked to generate multiple ideas (hypotheses) about the cause of the temperature difference.

(3) The third task, themed around "Boat," measures the effectiveness, feasibility, and uniqueness of hypotheses in the hypothetical space in the fields of physics and chemistry. An animated scenario about a toy boat and a mother with her daughter is presented. The mother presents a problem related to the toy boat and asks the daughter to think about it. Children are asked to generate as many ideas (hypotheses) as possible.

- *The experimental design consists of three tasks:*

(1) The first task, with the theme "Hamster", measures effectiveness, feasibility, and uniqueness in the biological laboratory space. In an animated film, a child and their father are

preparing a living area for hamster mice. The father points out some issues in the mice's living area and asks his son to make changes so that the mice can live there. The child is required to create as many changes as they can think of, which can be implemented by the child in the film.

(2) The second task, with the theme "Sand Tank," measures effectiveness, feasibility, and uniqueness in the physical laboratory space. A child is playing with a ball on a sand tank in an animated film and wants to make some changes in the sand tank to achieve a goal. The child is required to make as many changes as they can think of, which can be implemented by the child in the film.

(3) The third task, with the theme "Tunnel," measures effectiveness, feasibility, and uniqueness in the physical laboratory space. In the animated film, a child and their teacher are creating a toy car and a tunnel. They cannot achieve their goal of setting up the tunnel and must make some changes to complete their objective. The child is required to make as many changes as they can think of, which the child and their teacher in the film can do to achieve their goal.

During the evaluation process, the child watches an animation from one of the TOSCAC tasks. Then, the tester asks the child to answer questions verbally. The tester records all of the child's answers on a form. If necessary, the child can review the animation, and the tester can explain the items to the child to understand the issues better. The child has enough time to express all the answers that they can think of. Each test item is considered complete when the child says, "I have no other answers for this question." The evaluation process takes approximately 20 to 25 minutes, including observation time and the time for the child to answer.

2.2.3. Strategies to promote preschool children's scientific creativity

The most important characteristic of scientific creativity is the ability to generate a large number of hypotheses for a specific problem or situation. An important criterion for creativity in science is to think and act like scientists. However, this skill is not exclusive to scientists and can be developed in children from an early age through educational activities that promote creativity [14-15]. Children's scientific creativity is enhanced when they engage in activities that enable them to use scientific processes and exploration skills [18]. Such scientific activities model how scientists work and conduct research, which can encourage children to use different scientific skills, thereby contributing to the emergence of creative ideas and the development of scientific creativity [19]. In addition, limited scientific knowledge may lead to poor scientific creativity skills [20-21]. Therefore, teaching programs and scientific activities need to be carefully planned to promote scientific creativity [21].

The results of studies on this topic in ECE have consistently shown the potential of interdisciplinary and collaborative learning-based science education activities for developing children's scientific creativity. Children's scientific creativity can be effectively developed if teachers enhance the use of brain-based methods, divergent thinking, and micro-methods [24] [26]; inquiry-based learning [27-28], problem-based collaborative learning [5], outdoor exploration (Carrie Brandon Moore, 2022), open science exploration [29], or use art-based lenses to assess scientific creativity and promote creative transformation in science [30].

Ya-Ling Hou (2013) and Mo Xiaoyi (2009) concluded that to help children develop scientific creativity, an educational program should include the following elements: (1) valuing children's learning motivation and exploration inspiration; (2) providing challenging questions that connect children's past experiences and stimulate purposeful thinking; (3) arranging materials to inspire creative traits; (4) allowing sufficient playtime for children; (5) at a deeper level, providing suitable scaffolding to encourage systematic exploration; (6) encouraging children to discuss, check and help each other. [24] [26]

Similarly, Yıldız Taşdemir, C. (2021) [5] suggested the need to enhance (1) problem-based collaborative learning, (2) integration of science with various activities such as art, music, and literacy rather than applying isolated science activities, (3) providing opportunities for children to

use basic scientific skills such as observation, classification, prediction, measurement, reasoning, and scientific communication; (4) Children's scientific knowledge and creativity can be developed through appropriate age and developmentally suitable science exploration activities; (5) Strengthening activities that use three-dimensional materials such as blocks and manipulative toys to develop visual-spatial skills, thereby contributing to the development of children's scientific and creative abilities.

In the EU-funded research project "Creative Little Scientists," which was a long-term study, Teresa Cremin and colleagues (2015), as well as Stylianidou, F. and colleagues (2018), developed a conceptual framework by analyzing related literature. Their work highlighted the potential for integrating inquiry-based science and creativity-based approaches in science education in early childhood. The synthesized approach to teaching and learning science and creativity in the early years encompasses play and exploration, motivation and influence, dialogue and collaboration, problem-solving and decision-making, questioning and curiosity, reflection and reasoning, scaffolding by teachers, and children's participation. Additionally, the study redefined the concept of creativity in the early years of science education and emphasized the potential for creativity in the context of science exploration. [27-28]

The authors noted that in the process of organizing educational activities for children, teachers should (1) guide children in comprehensive exploration instead of intervening too much; (2) encourage children to explore and think about problems from multiple perspectives instead of hastily drawing conclusions; and (3) encourage young children to accumulate experiences rather than focusing too much on knowledge concepts [26]. Ya-Ling Hou (2009) and Mo Xiaoyi (2009) also emphasized the need to develop science creativity-oriented teaching programs for children. The involvement of families and communities positively affects children's science creativity development as well [22] [24] [26] [31].

Furthermore, Lehmann, J. & Gaskins, B. (2019) highlighted the use of the lens of artistic practice to evaluate creativity in science and promote transformation in science. The authors argue that successful implementation requires training through a long-term learning and learning process, organizing interactions to assess results, designing experiments for children to try and fail, and building shared and private spaces to promote chance encounters between academic and non-academic fields. [30]

2.2.4. Some research directions for the development of scientific creativity in preschool children

Upon analysis, it is evident that the topic of scientific creativity in preschool children has gained research interest globally in recent years. However, in Vietnam, the development of scientific creativity in preschool children has received limited coverage in scientific literature. Hence, future research could concentrate on the following topics:

(1) The process of developing scientific creativity in Vietnamese preschool children according to their age.

(2) Adapting/developing appropriate measurement tools for assessing scientific creativity in preschool children within the Vietnamese context.

(3) Investigating the correlation between general creativity and scientific creativity in Vietnamese preschool children.

(4) Evaluating the current state of scientific creativity in Vietnamese preschool children based on age, region, location, and gender.

(5) Developing methods, measures, and programs to promote scientific creativity among Vietnamese preschool children in both the home and preschool settings.

(6) Investigating the impact of STEM/STEAM approaches, project-based learning, and other

instructional approaches on the development of scientific creativity in preschool children.

(7) Creating materials, resources, and curricula for the professional development of early childhood educators to promote the development of scientific creativity in preschool children.

Pursuing these research directions will not only contribute to a solid theoretical foundation for the development of scientific creativity in preschool children but also have a positive impact on practical efforts to promote scientific creativity in both home and preschool settings.

3. Conclusion

This study aims to emphasize the necessity of promoting research and practical efforts to develop scientific creativity in preschool-aged children. Although the issue of scientific creativity in preschool children has been recognized and studied worldwide, the theoretical framework on this topic is still unclear and underdeveloped. In the context of early childhood education in Vietnam, the concept of scientific creativity is relatively new and has not been widely researched. Based on a clarification of the concept, nature, characteristics, and the process of developing scientific creativity in preschool-aged children, the authors propose several research directions on this topic.

This is an exploratory and problem-solving study. The content mainly draws on secondary literature from abroad to propose research directions in the context of Vietnam. Future research should continue to explore various related topics, providing a foundation for research and application in early childhood education in Vietnam.

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