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Research articles

From curiosity to science. Promoting scientific thinking in preschool

De la curiosidad a la ciencia. Fomentando el pensamiento científico en preescolar

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Abstract
This article presents a study that analyzed the development of scientific thinking in preschool children at the Luis Eduardo Mora Osejo School in Pasto, Colombia, through activities focused on the transformations of matter. The study aimed to foster curiosity and scientific reasoning through practical, accessible experiments tailored to the children's age. The qualitative methodology employed included direct observation and the use of field journals to document learning. The results show an increase in students' active participation, leading to a deeper understanding of material changes. Additionally, collaborative work and experimentation contributed to the development of skills such as observation, hypothesis formulation, and problem-solving, highlighting the effectiveness of this pedagogical strategy in early childhood education.

Keywords: preschool education; thinking; active learning; food transformations; curiosity.

Resumen
El presente artículo da cuenta de una investigación que analizó el desarrollo del pensamiento científico en niños de preescolar de la Institución Educativa Luis Eduardo Mora Osejo, en Pasto, Colombia; a través de actividades enfocadas en las transformaciones de la materia. El estudio se centró en motivar la curiosidad y el razonamiento científico mediante experimentos prácticos y accesibles, adaptados a la edad de los niños. La metodología cualitativa empleada incluyó observación directa y el uso de diarios de campo para registrar el aprendizaje. Los resultados muestran un incremento en la participación activa de los estudiantes, quienes lograron una comprensión más profunda sobre los cambios en los materiales. Asimismo, el trabajo colaborativo y la experimentación contribuyeron al desarrollo de habilidades como la observación, formulación de hipótesis y resolución de problemas, evidenciando la efectividad de esta estrategia pedagógica en la educación infantil.

Palabras clave: educación preescolar; pensamiento; aprendizaje activo; transformaciones de alimentos; curiosidad.

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INTRODUCTION

The development of scientific skills during early childhood is vital for fostering curiosity and critical thinking in children, particularly as they transition to the next stages of learning, where they show their capacity of exploration and experimentation. This phase is an opportunity to establish a strong foundation in scientific knowledge, taking advantage of children's natural receptiveness to new experiences and ways of knowing (Shonkoff; Phillips, 2000). According to Vygotsky, play and interaction with the environment are fundamental to their learning, enabling children to observe, experiment, and question their immediate surroundings (Vygotsky *apud* Gillies, 2016). However, in many educational contexts, these activities are not structured effectively, or their full potential for developing scientific skills is not fully done.

For this reason, the need to strengthen scientific thinking among kindergarten children has been identified, with particular focus on transformations of matter. This aspect is fundamental for children to understand the changes that materials can undergo in their shape, state, or appearance, which represents a first step toward a broad understanding of natural processes. By offering activities that children can observe and manipulate materials, an educational experience is promoted that facilitates the acquisition of basic scientific concepts and fosters an interest in science from an early age.

Several studies indicate that science education in early childhood plays a crucial role in fostering critical thinking skills and acquiring skills that will be essential in children's academic and social lives (Worth; Grollman, 2003). However, many educational settings face challenges due to limited access to activities that promote the development of these scientific skills. Resource limitations and a lack of specialized training for preschool teachers hinder the implementation of experimental practices in the classroom (Trundle; Sackes, 2015). This shows the need to structure pedagogical approaches that integrate science into the early childhood education curriculum, not only as an isolated subject but as a tool for children's holistic development.

To address this need, the research described in this article implemented a set of hands-on activities focused on the transformations of matter, as part of a teaching strategy designed to stimulate scientific thinking in preschool children. These activities, which included direct interaction with experts and the observation of everyday phenomena, enabled children to develop skills in observation, hypothesis formulation, experimentation, and analysis. This article examines the results of this experience carried out at the Luis Eduardo Mora Osejo Educational Institution, analyzing how these activities fostered an interest in science and promoted active and collaborative learning.

Scientific thinking in children is not just a skill reserved for adulthood or academia; it is a disposition toward the world that can be nurtured from an early age. Various studies emphasize that curiosity and wonder stimulate analytical and structured thinking from childhood, enabling children to explore and formulate questions about their environment (Gopnik et al., 2001; Piaget, 1972). Albert Einstein also emphasized that his discoveries stemmed from the same questions he asked himself during his childhood, suggesting that scientific thinking can and should begin in childhood (Ohanian, 2008).

Current theories in early childhood education highlight that young children are especially receptive to developing scientific skills through experiences that stimulate their natural curiosity and allow for active exploration (Eshach; Fried, 2005). In this sense, the educational approach promoted by the Ministry of National Education (Colombia, 2019) emphasizes the importance of activities such as play, exploration, and art, key elements for holistic development and to stimulate critical thinking in early childhood.

Learning through experimentation and discovery is particularly valuable because it not only facilitates the acquisition of knowledge but also promotes observation, analysis, and problem-solving skills in students (Bruner, 1961; Piaget, 1972). While some studies explore the use of play-based and scientific activities to develop skills in preschool children, specific research on experiments concerning the transformations of matter in this age group remains limited (Fleer, 2009). This gap in the literature justifies the relevance of the study that gave rise to this article on how the use of home experiments and practical activities can promote scientific thinking in preschool children.

The study has the following research question: How do exploration and experimentation activities contribute to the development of scientific thinking in preschool students? Thus, the overall objective was to develop scientific thinking in kindergarten children by conducting at-home experiments that explore and connect the concepts of matter transformation. Specific objectives included (a) identifying basic concepts about matter transformation through age-appropriate experiments, (b) creating challenging situations that stimulate hypothesis formulation and reflection, and (c) enhancing teamwork skills in collaborative science activities.

Research in early childhood science shows that engaging with the environment and conducting simple experiments are fundamental for fostering curiosity and critical thinking. For example, Bruner (1961) advocates a constructivist approach to early childhood learning, where children discover principles through direct experiences with the physical world. The concept of "discovery learning" (Bruner, 1961) emphasizes that learning is most effective when children explore and discover concepts independently rather than passively receiving information. In the preschool context, simple experiments allow children to interact with their environment, formulate questions, and generate hypotheses, promoting active and participatory learning. This approach is also compatible with Vygotsky's (1978) theory of the Zone of Proximal Development (ZPD), which suggests that learning is most effective when it occurs with the help of an adult or a more advanced peer, creating a collaborative and supportive space for knowledge construction.

Finally, it is important to highlight that the Colombian Ministry of Education (Colombia, 2019) emphasizes the importance of a stimulating educational environment for children's holistic development. An enriching environment not only promotes the development of cognitive skills but also fosters social and emotional capacities from an early age. This project aligns with these principles by providing experiences that stimulate scientific thinking and promote emotional and social development through collaborative activities and hands-on experiments.

In conclusion, the importance of scientific curiosity, discovery learning, social support, and comprehensive early childhood care as pillars for the development of scientific thinking in children is evident. This article supports the need to strengthen scientific thinking in children through a hands-on approach that explores the transformations of matter through play-based activities.

METHODOLOGY

This article used a qualitative research approach. According to Hernández, Fernández and Baptista (2014), qualitative research seeks to explore the complexity of educational phenomena and understand participants' individual experiences from their own perspectives. This method captures the internal dynamics of children's thinking as they interact with their environment and experimental materials. In contrast to quantitative research methods, which focus on measuring variables and establishing statistical relationships, this study examined how kindergarten children develop their scientific reasoning skills through the observation of natural phenomena, such as changes in the state of matter and the mixing of substances. Additionally, it analyzed the role of the educational environment and the interactions between teachers and students in fostering scientific skills at an early age.

Regarding the design, a case study approach was used, recommended for in-depth qualitative research. This method allows for a detailed observation of the experience of a specific group of students, in this case, preschoolers, within their particular context, without the intention of generalizing the findings to other populations. This design is well-suited to the research objective, as it provides a rich and contextualized view of the preschool learning process. Data collection was carried out through direct observation and the use of field notes, essential methods for capturing the spontaneity of the children's interactions and the cognitive strategies they employ during experimental activities (Creswell, 2013).

The study population consisted of kindergarten children at the La Minga campus of the Luis Eduardo Mora Osejo Educational Institution in Pasto, Nariño Department, Colombia. Children of this age exhibit a high receptiveness to direct experiences, a key element for scientific learning through experimental activities (Gelman; Brenneman, 2004). The sample was purposive and comprised 25 preschool children, selected based on their level of participation in prior science activities and their interest in learning science. In qualitative research, a statistically representative sample is not necessary; rather, the aim is to delve into the experiences of the selected participants to gain a detailed understanding of the phenomenon (Patton, 2015). It is important to note that the children's participation in the research was managed in accordance with the ethical principles of educational research, respecting their privacy and anonymity. Parents and guardians were informed about the objectives of the study, and informed consent was obtained for the participation of the children, who were involved in a safe and respectful environment (American Psychological Association, 2017).

A direct observation was one of the methods used during the experimental activities, enabling researchers to capture the children's spontaneous reactions. This non-intrusive approach allowed for the observation of both individual responses and group dynamics, as well as the cognitive strategies the children employed, such as deductive and inductive reasoning (Berk, 2008). The observations were recorded in detail to facilitate subsequent analysis of the children's reactions and reflections on the phenomena they observed. Additionally, the children's responses and their cognitive and emotional development over time were documented in a field journal (Spradley, 2016). This resource provided insight into the children's progress in understanding scientific concepts and aided in identifying patterns of thought and scientific curiosity.

The research was organized into four stages to maximize children's interaction with scientific concepts through hands-on experiences. Each stage is described below:

Stage 1. Introduction to the transformations of matter: This stage involved a presentation adapted to the children's age, using visual aids and examples from their daily lives to introduce the concept of matter transformation (e.g., melting ice). This initial phase sought to motivate the children to ask questions and explore their surroundings, fostering a sense of wonder and curiosity.

Stage 2. Experimental Activities: In this phase, the children participated in simple experiments designed to observe changes of state in matter, such as making ice cream or melting ice cubes. These hands-on activities allowed the children to observe changes in matter and develop observation and analytical skills.

Stage 3. Observation and Hypothesis Formulation: After each experiment, small group discussions were held where the children shared their observations and formulated hypotheses. This stage is crucial for fostering critical thinking and reasoning skills, as it allows children to reflect on and consider the possible causes of the observed phenomena (Tharp; Gallimore, 1998).

Stage 4. Field Diary Recording: The teacher-researchers documented both individual observations and group dynamics in their field diaries. This record provided a key resource for qualitative analysis and allowed the researchers to track the children's cognitive development throughout the project (Creswell; Poth, 2017).

It is important to note that the collected data were analyzed using thematic coding, identifying patterns of thought and skills in the children's development of their understanding of the transformation of matter (Braun; Clarke, 2006). This analytical approach is particularly well-suited to understanding the emotional and cognitive aspects of learning in young children. Additionally, a data triangulation process was carried out, comparing the recorded observations with the group interactions and the children's individual responses. This triangulation technique offered a holistic view of the learning process, allowing for the validation and enrichment of the findings (Flick, 2018).

RESULTS

The educational innovation project that gave rise to this article, designed to foster scientific thinking in preschool children through the exploration of the transformations of matter, revealed several significant advances in their cognitive, emotional, and social development. Detailed findings for each of the observed areas are presented below.

A significant increase was observed in the children's ability to formulate questions. They showed notable progress, moving from simple inquiries to more complex ones, such as "Why does ice change shape?" This finding suggests an evolution in their critical thinking skills, consistent with previous studies that highlight how encouraging curiosity and environmental exploration at an early age promotes the development of scientific skills (Nielsen, 2019). Additionally, this ability to ask complex questions emphasizes the importance of early science education in fostering critical thinking and scientific inquiry (Crowley et al., 2001).

Improvement in scientific predictions. During the experimental activities, the children made predictions about changes of state of matter, demonstrating an increasing understanding of basic scientific concepts. Many children correctly predicted the outcome of ice melting when heat was applied, indicating that they understood both the phenomenon and the conditions that produce it. These findings support research suggesting that participation and experimentation enable children to develop a deeper understanding of complex scientific concepts (Gelman; Brenneman, 2004).

Identification of Basic Scientific Concepts: Students demonstrated the ability to identify and name key concepts such as melting, freezing, and mixing by observing the changes of state in the materials used during the experiments. This skill in recognizing and using basic scientific terminology indicates progress in their understanding and enables them to connect their observations with the theoretical concepts discussed in class. According to Osborne and Dillon (2010), early exposure to scientific terminology promotes a deeper and more enduring understanding and enhances the development of analytical skills.

Understanding changes of state when heat or cold is applied. Hands-on activities, such as making ice cream and observing the cooking process of arepas, allowed children to observe how ingredients change state when heat or cold is applied. This direct relationship between theory and practice strengthened their understanding of the transformations of matter and gave them a real-world context for scientific concepts. Studies such as those by Driver et al. (2014) affirm that learning through sensory experiences is fundamental for consolidating concepts at an early age.

The development of analytical and reflective skills is crucial for children's learning. Using an observation notebook allowed them to reflect on their experiences in an organized manner. By recording their observations and thoughts during experiments, the children enhanced their analytical and self-observation skills. Researchers such as Vygotsky (1978) have identified this type of personal reflection as a practice that strengthens children's ability to think abstractly and analytically. The structured format of the notebook provided them with a valuable tool to connect their observations with the scientific concepts discussed in class, promoting deeper and more contextualized learning.

Promoting collaboration and teamwork. Group activities, including post-experiment discussions, fostered collaboration among the children, who shared observations and formulated hypotheses together. This collaborative approach strengthened both their scientific learning and interpersonal skills, as they were taught to respect each other's ideas and to work as a team. According to research by Johnson and Johnson (2009), collaborative learning promotes the development of social skills and facilitates a deeper understanding of the content by allowing for the sharing of different perspectives.

Strengthening the ability to explain and justify observations. Group discussions allowed children to structure their thoughts and express their observations more logically and coherently. Through these discussions, they developed argumentation and oral communication skills, which are fundamental to their cognitive and social development. Chi and Wylie (2014) highlight that the process of explaining and justifying thoughts significantly improves the retention and understanding of scientific knowledge.

Enriching understanding through interaction with experts. Visits to the "Science House" and talks with local experts, such as bakers and dairy farmers, allowed children to see the real-world application of scientific concepts. These interactions provided a real-world context for learning, increasing their understanding and motivation toward science. This experiential learning approach has proven effective in studies by Barton and Tan (2010), who argue that contact with professionals who apply science in their daily lives provides children with a tangible insight into scientific careers and their importance in the real world.

Motivation and commitment to scientific learning. Hands-on experiences and contact with people who apply scientific knowledge significantly increased children's motivation. By seeing the relevance of science in everyday life, students showed greater interest and enthusiasm, which was reflected in their participation and the questions they asked. According to Howe and Abedin (2013), students become more engaged in learning when they feel it has a clear purpose and practical applications in their environment.

Expression of Ideas and Discoveries at the Science Fair. The science fair allowed children to present their ideas and discoveries in a creative and tangible format. The projects presented reflected a deep understanding of the concepts covered, such as changes of state and the mixing of substances. This activity also boosted their self-esteem by allowing them to celebrate their achievements and showcase what they had learned. As suggested by studies by Allen (2014), public presentation activities strengthen communication skills and provide students with an opportunity to consolidate their learning.

Strengthening teamwork and communication skills. Collaboration on science fair projects helped children improve their teamwork and communication skills. By working in groups, they shared responsibilities and solved problems together, strengthening their social and communication skills. Studies on collaborative learning, such as Slavin's (2014), highlight the importance of these skills for holistic development and children's ability to express and defend their ideas in an environment of mutual respect.

DISCUSSION

The findings of this study support previous research that underscores the importance of active learning and discovery in early childhood education. Scholars such as Fleer (2014) have emphasized that introducing science and technology at a young age not only stimulates cognitive development but also nurtures children's innate curiosity. Similar to the study that inspired this article, these researchers assert that active learning, enhanced by hands-on and technological experiences, leads to a more profound understanding of natural phenomena. Additionally, Shepherd (2006) highlights that scientific curiosity is a key factor in the development of children's scientific thinking. This point is reflected in the focus of this work on promoting exploration, observation, and the formulation of hypotheses.

Additionally, this study adds a specific dimension regarding peer collaboration, interaction with experts, and visits. Although the literature mentions the importance of these factors in learning, their practical implementation at this educational level is rarely explored. Interaction with professionals, such as bakers and dairy farmers, as well as visits to key locations, gave children a direct and applied view of how scientific knowledge is used in daily life, an aspect that is not usually addressed in other studies on early childhood education (Worth; Grollman, 2003).

These activities helped children visualize how the scientific principles they were studying apply to everyday situations, which increased their curiosity and motivation. According to Eshach and Fried (2005), linking theory to practice not only reinforces learning but also fosters a sense of relevance and purpose among students. Additionally, the study's structure allowed for the customization of activities, adapting them to meet each child's individual pace and needs. This approach promotes an effective and adaptive learning experience that strengthens understanding and enhances the retention of scientific concepts in early childhood.

Another key aspect was the collaborative approach, which fostered the development of both scientific and social skills. Working in teams allowed children to share observations, discuss hypotheses, and collaborate on problem-solving, boosting their communication and logical reasoning skills. This dynamic strengthened social interaction, conflict resolution, and negotiation—essential competencies for their holistic development.

The variability in family contexts and access to resources outside the classroom were among the main limitations of the study. Although the experiments were designed to be accessible, some children lacked the necessary resources to replicate them at home, which affected their participation in extracurricular activities and their overall understanding of the concepts. This situation highlighted the importance of designing educational programs that consider the diversity of family contexts and access to resources.

Another significant limitation is the sample size, which, while adequate, does not allow for broad generalizations across all educational contexts in the region. Future studies would benefit from expanding the sample and including diverse institutions to assess the effectiveness of these methodologies in varied contexts.

CONCLUSIONS

Research conducted at the Luis Eduardo Mora Osejo Educational Institution has effectively demonstrated that the development of scientific thinking in preschool children can be enhanced through hands-on activities focused on the transformation of matter. By using simple, home-based experiments adapted to the children's abilities, their natural curiosity was encouraged and active learning was facilitated, allowing them to observe, reflect, and experiment with changes in everyday materials. This approach has created a tangible link between scientific concepts and the students' daily lives, a crucial aspect for early childhood learning (Worth; Grollman, 2003).

A key finding of this research is the importance of linking scientific concepts to practical, real-world applications. Interacting with experts and conducting experiments that mimic familiar natural processes—such as making ice cream or melting ice—helped children grasp the relevance of science in their everyday lives. These experiences enabled them to form clear connections between theory and practice, enhancing their understanding of matter transformations and developing cognitive skills like observation and hypothesis formulation.

The results also show a notable increase in children's interest and active participation in the learning process, which translates into a deeper understanding of fundamental scientific concepts. This approach fosters key skills such as prediction and problem-solving, while also developing critical thinking, an essential competency for their future academic and personal success (Trundle; Sackes, 2015). The research thus highlights the importance of incorporating hands-on activities into early childhood education, promoting children's active participation in their own learning.

The study also underscores the value of collaborative work as a core component of science learning. Through teamwork activities, children not only learned scientific concepts but also acquired essential interpersonal skills, such as effective communication and collaboration. These skills are fundamental to their holistic development, preparing them to face challenges in future educational contexts and in their social lives (Gillies, 2016). The ability to work as a team, discuss ideas, and respect different points of view fosters an enriching and positive learning environment.

In conclusion, the qualitative methodology employed, based on direct observation and the use of field notes, was effective in documenting the learning process and evaluating the impact of the activities. This methodology not only allowed for recording the children's progress but also provided valuable information about classroom dynamics and the effect of the activities on their cognitive and social development.

Future research should explore how this approach can be adapted and expanded to include other areas of knowledge, such as mathematics or engineering, through interdisciplinary activities. This type of approach should be considered in other educational contexts, adapting it to the characteristics and needs of the students to maximize its effectiveness.

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