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STEAM as a strategy to strengthen scientific thinking in early education

STEAM como estrategia para fortalecer el pensamiento científico en la educación inicial

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Abstract

This article examines the implementation of the STEAM approach (Science, Technology, Engineering, Arts, and Mathematics) in early childhood education as a strategy to strengthen scientific thinking in kindergarten students. Based on an experience carried out in three educational institutions located in Nariño and Sucre, Colombia, the study highlights how the creation of school gardens, within the framework of a pedagogical project, served to integrate scientific knowledge and local cultural traditions. Through a qualitative approach, children's interactions with their natural environment were analyzed, promoting observation skills, hypothesis formulation, and problem-solving. Additionally, the active participation of families and the community in the development of the project enabled meaningful and contextualized learning. The results show that the STEAM approach, combined with the Project-Based Learning (PBL) methodology, not only fosters curiosity and critical thinking but also strengthens collaboration and commitment to the environment, offering a more inclusive and culturally relevant education.

Keywords: active learning; community; critical thinking; pedagogical innovation.

Resumen

Este artículo examina la implementación del enfoque STEAM (Ciencia, Tecnología, Ingeniería, Artes y Matemáticas) en la educación inicial como una estrategia para fortalecer el pensamiento científico en estudiantes de grado transición. Basado en una experiencia llevada a cabo en tres instituciones educativas colombianas ubicadas en Nariño y Sucre, el estudio destaca cómo la creación de huertas escolares, en el marco de un proyecto pedagógico, sirvió para integrar conocimientos científicos y tradiciones culturales locales. A través de un enfoque cualitativo, se analizaron las interacciones de los niños con su entorno natural, promoviendo habilidades de observación, formulación de hipótesis y resolución de problemas. Además, la participación de las familias y la comunidad en el desarrollo del proyecto permitió un aprendizaje significativo y contextualizado. Los resultados evidencian que el enfoque STEAM, junto con la metodología de Aprendizaje Basado en Proyectos (ABP), no solo fomenta la curiosidad y el pensamiento crítico, sino que también fortalece la colaboración y el compromiso con el entorno, ofreciendo una educación más inclusiva y culturalmente relevante.

Palabras clave: aprendizaje activo; comunidad; pensamiento crítico; innovación pedagógica.

INTRODUCTION

The STEAM approach, which integrates the disciplines of Science, Technology, Engineering, Arts, and Mathematics, has emerged as an innovative educational strategy aimed at promoting scientific and critical thinking from the earliest years of schooling. This article is

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based on experiences from the transition grade of three Colombian educational institutions: Juanambú, located in the urban area of the Nariño department, with a diverse student population; and two schools located in the Sucre department: Etnoeducativa Pajonal in the municipality of San Onofre, with an Afro-Colombian population, and Técnico Agropecuario La Arena in the La Arena district of Sincelejo, with an Indigenous population. This cultural and demographic diversity enabled the development of the same pedagogical innovation proposal across three contexts within the framework of the *Ondas Primera Infancia* project, which not only focuses on pedagogy but also recognizes and values the cultural traditions of the communities involved.

STEAM (Science, Technology, Engineering, Arts, and Mathematics) has emerged as an innovative strategy for strengthening scientific thinking in early childhood education. This approach integrates traditional disciplines with the arts, offering students a more holistic and problem-solving-oriented educational experience. Rather than teaching science and mathematics in isolation, STEAM promotes an interdisciplinary methodology that enables children to explore and apply scientific concepts in a more creative and applied context. Thus, at the preschool level, STEAM is a powerful tool because it harnesses children's natural curiosity to explore the world around them. Through experimentation-based projects, children not only acquire specific knowledge in science and technology but also develop social skills such as collaboration and effective communication (Sánchez Ludeña, 2019).

The adequate preparation of teachers is one of the main challenges to implementing the STEAM approach in early childhood education. In many cases, preschool teachers lack the necessary training to effectively integrate STEAM disciplines into their teaching, which can generate uncertainty and anxiety regarding their role in the classroom. This challenge gets worse when there is a lack of educational resources or institutional support for developing these types of programs. However, ongoing training and access to appropriate pedagogical tools can improve educators' confidence and, consequently, the quality of STEAM teaching in the early years (Quigley; Herro; Jamil, 2017).

The introduction of the STEAM approach in early childhood education, integrated with active methodologies such as Project-Based Learning (PBL), has been an effective tool for motivating students by actively making them explore real-world problems. The school garden is a central strategy for implementing STEAM, facilitating the connection between children's interests and the practical application of scientific concepts. According to Barron and Darling-Hammond (2008), Project-Based Learning "enables students to become deeply involved with the content, developing not only academic skills but also problem-solving, communication, and critical thinking abilities" (p. 24). The school garden not only acts as a space for learning about the plants and animals around it, but also fosters collaboration, creativity, and intergenerational learning, as noted by Torres-Ruiz, Peña and Morales (2022), thanks to the family participation.

In the context of this project, the children asking "How can I plant seeds?" or "Can slugs harm plants?" reflected a natural interest in their surroundings and were the starting point for scientific inquiry. Through the garden, the students not only learned about plant life cycles and the importance of caring for the environment, but also developed observation and experimentation skills, fundamental to scientific thinking.

Project-Based Learning, as a methodology, encouraged children to take an active role in their education. When combined with the STEAM approach through activities such as cultivating and maintaining the school garden, it creates a meaningful learning environment. The Interdisciplinary nature of the STEAM approach encourages students to think critically about complex problems and find innovative solutions. It also fosters scientific curiosity, promotes the development of essential competencies such as problem-solving and teamwork, while exploring themes of sustainability and environmental stewardship.

This project also highlighted the significance of integrating local traditions within the classroom. By working together with the community, children were able to explore scientific concepts through a STEAM approach that also respects and values the customs and knowledge of their

families. This initiative aligns with the Colombian Ministry of National Education (Colombia, 2017), which emphasizes the importance of contextualizing educational processes to ensure they are relevant to local contexts. By using the school garden as the project's central focus, students not only develop a scientific understanding of their environment but also create opportunities for families and the community to be involved in the educational process. This will strengthen a sense of belonging and the transmission of knowledge across generations. This combination of the STEAM approach, Project-Based Learning (PBL), and cultural traditions was a successful educational strategy for strengthening scientific thinking in early childhood education, while simultaneously promoting a more inclusive and contextualized education (Quigley; Herro, 2016).

METHOD

A qualitative approach was used to develop the research project entitled "Harvesting Dreams in the Garden with the Families of Kindergarten Students at the Juanambú, Pajonal Ethno-educational, and La Arena Agricultural Technical Schools during the 2024 School Year," (*"En el vergel cosechando sueños con las familias del grado transición de las instituciones educativas Juanambú, Etnoeducativa Pajonal y Técnico Agropecuario La Arena durante el año escolar 2024"*), which was the foundation for this article. According to Moreira (2002), the main objective of qualitative research is to interpret the meanings individuals give to their actions within a specific context. This approach enables us to understand reality from the perspective of those involved, allowing for a comprehensive explanation of the phenomenon being investigated. The overall goal of the research was to enhance scientific and critical thinking through projects that arise from the interests and needs of kindergarten children, considering the STEAM approach for developing competencies and skills in solving everyday problems.

The qualitative approach focuses on how events unfold by exploring people's attitudes, beliefs, and behaviors about their environment (Lichtman, 2013). This approach can also be descriptive, which involves recording, analyzing, and interpreting phenomena, their characteristics, and their processes (Tracy, 2010). In this project, describing the implementation of the STEAM approach in the three educational institutions is crucial for evaluating its potential to enhance scientific thinking in preschool children, Also, it examines how the school garden becomes not only an educational tool but also as a meeting point between the cultural traditions of the communities and the knowledge, skills, and competencies that children are expected to learn at this early stage, promoting contextualized and meaningful learning.

The study population consisted of kindergarten children from the three participating educational institutions. The sample was non-probabilistic, as all children participated voluntarily and had an equal chance of being selected. A total of 77 boys and girls between 5 and 6 years old from the three institutions participated in the study. The children are at a key stage of cognitive and psychological development in which skills such as curiosity, active exploration of the environment, and learning through play are fundamental.

At a cognitive level, children of this age are in what Piaget refers to as the preoperational stage. During this stage, symbolic thought and the imaginative are predominant, although children have not yet developed the logical reasoning skills that will appear later (Piaget, 1952). In this sense, activities that promote exploration and learning through discovery are essential, as they enable children to make connections between the world they observe and the abstract concepts they are beginning to develop.

In psychological terms, Erikson (1959) describes this period as a phase in which children face the challenge of initiative versus guilt. In other words, they have a growing motivation to start activities and make decisions for themselves, which makes self-directed learning experiences, such as those offered in STEAM-based projects, especially beneficial. These experiences not

only promote critical thinking and problem-solving but also help develop self-confidence and teamwork skills (Quigley; Herro; Jamil, 2017).

This stage is characterized by the rapid development of language and fine motor skills, enabling children to actively participate in activities involving manipulating materials and using language to describe and analyze their experiences (Berk, 2020). Therefore, implementing a project like the school garden, within the STEAM framework, provides children with a rich platform for hands-on learning and the application of their emerging skills.

The research that led to this article used observation as a key technique to gain a closer understanding of children within their everyday environments. This allowed researchers to analyze how the students interact with the garden, their perceptions of activities related to plant care, and how these experiences influence their scientific and critical development. According to Angrosino (2018), observation is a valuable method in qualitative research because it allows the researcher to integrate into the environment and capture the social and educational dynamics firsthand.

The field journal served as a key tool for documenting the experiences and perspectives of both the students and their families. This journal acts not only as a data record but also as a way for capturing the teacher-researcher's personal thoughts, emotions, and internal perceptions (Emerson; Fretz; Shaw, 2011). In this project, the field journal facilitated the systematic organization of the most relevant moments of the educational experience, providing valuable information about the impact of the STEAM approach on the research population.

The creation of the school garden as part of this project enabled students not only to acquire knowledge about science and technology but also to develop important problem-solving and collaboration skills. The garden offers an ideal context for integrating the STEAM approach with local customs and traditions, enriching the educational experience. According to Kelley and Knowles (2016), project-based learning, such as the school garden development, fosters a deeper connection between students and the scientific concepts they are learning. It also allows children to see the practical application of science in their daily lives, reinforcing their interest and curiosity.

RESULTS

The development of the "Harvesting Dreams in the Garden" project demonstrated the positive impact of implementing the STEAM approach on strengthening the scientific and critical thinking skills of preschool students. Through the creation and maintenance of the school garden, the children actively participated in activities that fostered their natural curiosity and ability to solve problems creatively. The results showed that the students not only acquired knowledge about the plant life cycle, crop care, and the importance of sustainability, but also developed key social skills such as collaboration and teamwork, fundamental elements in project-based learning (PBL).

Based on the field notes and teacher observations, the children showed an improvement in their scientific inquiry skills, including formulating hypotheses, making detailed observations, and asking relevant questions. These skills are essential for developing scientific thinking from an early age (Yakman; Lee, 2012). The STEAM approach helped students connect the concepts they learned in the classroom with their immediate environment, facilitating meaningful and contextualized learning. This aligns with previous studies suggesting that project-based learning that includes interaction with the natural environment significantly improves children's cognitive and emotional development (Lou et al., 2021).

Greater family participation in the educational process was observed, a key factor for the success of the STEAM approach at this stage of education. Families actively contributed to maintaining the garden, sharing their traditional knowledge of plant cultivation, further enriching the educational experience. Therefore, integrating the community and families into educational projects increases the relevance of learning and strengthens the bonds

between school and home, which in turn benefits the holistic development of children (Yakman, 2008).

The differences observed among the participating institutions showed that, while all schools successfully implemented the STEAM approach, each made adjustments to address specific logistical challenges, such as a lack of resources, climate, water scarcity, or the availability of specific products in different areas. These actions allowed a greater integration of local cultural practices into the project, resulting in a more enriching and personalized educational experience. Research suggests that integrating ancestral and cultural knowledge into the curriculum can positively impact students' motivation and academic performance, especially in rural or marginalized contexts.

In conclusion, this project's results show that implementing the STEAM approach through creating a school garden was highly effective in developing scientific and critical thinking skills in preschool children. The project also fostered family involvement and facilitated the integration of local cultural knowledge, contributing to a more inclusive and meaningful learning experience.

DISCUSSION

The STEAM approach has demonstrated its effectiveness as a robust educational tool for strengthening scientific thinking among students in early childhood education. In the context of the study that created this article, the implementation of a school garden, based on the STEAM methodology and using Project-Based Learning (PBL), not only facilitated the integration of the disciplines of Science, Technology, Engineering, Arts, and Mathematics but also respected and valued the cultural traditions of the communities involved.

One of the most significant findings of this project was its positive impact on the development of scientific and critical thinking skills in kindergarten children. Through hands-on activities in the school garden, students developed observation, hypothesis formulation, and problem-solving skills, all essential for scientific thinking. These skills were enhanced by the interdisciplinary STEAM approach, which connects abstract concepts to children's daily lives, facilitating meaningful and contextualized learning (Lou et al., 2021).

The PBL methodology also allowed students to actively engage in their learning process, fostering curiosity, creativity, and collaboration. This participation is key to developing social skills such as effective communication and teamwork, evident in the results observed in the three participating educational institutions. The involvement of families in the school garden reinforces the idea that learning should not be an isolated experience, but rather one intrinsically linked to the community and the student's environment (Yakman, 2008).

Another crucial aspect of this project was the ability of the teacher-researchers to adapt the educational proposal to the specific cultural and geographical contexts of each institution. The three participating communities, characterized by their diverse compositions, including Afro-descendant, Indigenous, and urban populations, were able to integrate ancestral and local knowledge into the gardening activities, further enriching the educational experience. This integration of cultural knowledge aligns with the recommendations of the Colombian Ministry of National Education (Colombia, 2017), which emphasizes the importance of contextualizing educational processes to ensure their relevance within local contexts.

Finally, it is important to highlight that the main challenge identified in this study was the need to adequately train teachers to implement the STEAM approach. Teachers at the early childhood education levels often lack the necessary training and resources to implement these strategies, which can generate some resistance or insecurity (Quigley; Herro; Jamil, 2017). However, the results of this project show that, with appropriate training and institutional and family support, educators can overcome these barriers and use STEAM effectively to foster critical thinking and problem-solving skills in children.

CONCLUSIONS

The STEAM approach enables the creation of meaningful learning environments that respond to the needs and interests of students and their families, fostering scientific and critical thinking from a collaborative and team-based perspective (Guyotte, 2019; Yakman; Lee, 2012). This project has shown that family involvement not only strengthens children's socio-emotional development but also improves their understanding of health and well-being topics, such as adopting healthier eating habits (Lou et al., 2021).

Environmental awareness and social responsibility have also been promoted through activities such as the creation of school gardens in each institution, allowing children to engage in meaningful experiences that foster curiosity and respect for the environment, in line with current proposals on project-based learning and sustainable education (Yakman, 2008). The school garden stood out as a motivating and innovative experience that not only facilitated dialogue and interaction among peers but also allowed students to investigate, explore, and construct new meanings (Quigley; Herro; Jamil, 2017), as well as work hand in hand with their families.

Thanks to this innovative educational experience, it was possible not only to promote scientific thinking but also to create an inclusive learning space directly connected to the children's reality and context. The results of this study support the idea that integrating disciplines, local knowledge, and community support are key to a more meaningful and effective education. With appropriate training, teachers can use the STEAM approach to prepare students from an early age to face future challenges such as sustainability and human development (Guyotte, 2019).

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Authors contribution

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