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COMPUTATIONAL THINKING IN PRESCHOOLERS

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Abstract
The article explores the integration of computational thinking into early childhood education, aiming to evaluate how this approach can be implemented from the earliest stages of learning. The research employed a qualitative methodology based on a literature review, analyzing 17 studies published between 2015 and 2024, sourced from journals indexed in Scielo, SCOPUS, and Google Scholar. The reviewed studies focused on teaching strategies and technological tools applied in the preschool context. The findings indicate that computational thinking, encompassing skills such as sequencing, logic, and problem-solving, is essential for the holistic development of children in a digital environment. The tools and methodologies used have proven effective in introducing these concepts at an early age. However, the importance of adapting educational strategies to cultural and contextual specifics to optimize their effectiveness is highlighted. In conclusion, the early integration of computational thinking in preschool education facilitates a structured and creative way of thinking, which is fundamental for learning across various disciplines. Innovative strategies and the appropriate use of technology can transform early childhood education by fostering cognitive and creative skills. Continued research and development of educational approaches that adapt to different cultural contexts are necessary to better prepare students for the challenges of a digital and globalized future.
Keywords: computational thinking, early childhood education, sequencing, logic, problem-solving, technological tools, educational strategies, holistic development.

I. INTRODUCTION

The integration of Information and Communication Technologies (ICT) in multiple sectors of activity and social participation has produced a notable advance in contemporary dynamics. This progress has led to a review and adaptation of approaches in education systems, with the aim of developing essential skills and competencies to face the challenges of the emerging social ecosystem (García & Hernández, 2013; Henriksen et al., 2018). In this framework, the need to incorporate computational thinking and provide active exposure to digital technologies in the school curriculum has arisen (Nardelli & Ventre, 2015; Roman et al., 2017). This transition has led educators, academics, and researchers to highlight computational thinking as a fundamental form of literacy for the twenty-first century, emphasizing the need to establish a solid foundation in this competence at all educational levels, from early childhood education to higher education (Barr & Stephenson, 2011; Grover & Pea, 2013; Shute &Asbell, 2017).

Computational thinking (CP) has emerged as a concept of increasing relevance in the educational field in recent years. This growing interest has resulted in a significant expansion of research globally. However, a clear consensus has not yet been reached on its definition or on the skills and competencies involved in its integration into the education system (Acevedo & Medina, 2024). Despite this lack of consensus, the PC is widely recognized as a crucial problem-solving skill, particularly in the context of computer science and programming.

According to Wing's (2011) definition, computational thinking involves the process of formulating and solving problems in a way that solutions are effectively executable by information processing agents, whether humans, computers, or a combination of both. This approach is based on skills such as abstraction, decomposition, and algorithmic thinking (Selby & Woollard, 2013; Wing, 2008, 2011; National Research Council, 2010). Specifically, it encompasses problem-solving skills, including problem analysis, simplification through decomposition into smaller parts, developing algorithms or plans composed of sequences of steps and instructions, and verifying the achievement of set goals (Roman-Gonzalez et al., 2017).

It is crucial to underline that computational thinking techniques are not limited to the use of computers; they can also be applied to everyday problem-solving situations (Wing, 2006). These skills are expected to impact not only problem-solving, but also the development of related cognitive skills (Di Lieto et al., 2017; Fessakis et al., 2013). From this perspective, computational thinking is not only valued by computer professionals, but its applicability extends to various fields such as literacy, art, journalism, biology, engineering, mathematics, and science (National Research Council, 2010; Selby &Woollard, 2013).

Despite support from researchers on the importance of integrating computational thinking from early childhood, there is a significant gap in research on the development of these skills in young children (Bers, Flannery, Kazakoff, & Sullivan, 2014; Botički, Pivalica, & Seow, 2018). Although empirical studies have been conducted in primary and secondary education, preschool education has received less attention (Bers et al., 2014; Angeli & Valanides, 2020). In this context, the research community has enthusiastically adopted educational robotics in the last decade as a strategy to teach computational thinking to early childhood education students (Benitti, 2012; Bers, 2010).

In recent times, computational thinking has played a central role in educational innovation, transforming schools into technological literacy environments (Bers et al., 2019; Manches & Plowman, 2017; Zapata-Ros, 2015). This trend has even extended to early childhood education, where, in the second cycle (from three to six years old), technology is being incorporated into the classroom, facilitating access to the teaching of robotics and programming for younger students (Bers et al., 2014). Children at this stage demonstrate a remarkable ability to develop simple robotics projects (Cejka et al., 2006; Kazakoff et al., 2013), learn basic programming principles, and acquire computational thinking skills. This suggests that robotics and programming not only foster cognitive, motor, and social development in young children, but also have a positive impact on mathematical problem-solving (Bers et al., 2013; Lee et al., 2013; Resnick et al., 1998).

Thus, computational thinking has established itself as an essential competence in contemporary education, standing out for its ability to equip students with key skills in solving complex problems through structured mathematical and scientific concepts (Grover & Pea, 2013; Wing, 2006; Barr, Harrison, & Conery, 2011). This skill not only boosts creativity and innovation, but also reinforces collaboration among students, preparing them to face the challenges of the modern world (Grover & Pea, 2013; Barr, Harrison, & Conery, 2011). In addition, computational thinking fosters the development of analytical skills and the ability to solve problems efficiently (Wing, 2006). However, its effective integration into education faces important challenges, such as the need for adequate teacher training and the limited accessibility to technology in many educational institutions (Grover & Pea, 2013; Wing, 2006).

For a successful implementation of computational thinking (CP) in education, it is essential to adopt a comprehensive approach that includes both adequate training of educators and equitable access to technological resources (Grover & Pea, 2013; Wing, 2006). Teacher training is a critical component, as recent research has highlighted that empowering teachers to effectively integrate computational thinking into the school curriculum not only improves students' digital competencies, but also enhances their ability to meet real-world challenges through logical reasoning and the application of algorithms (Barr, Harrison, & Conery, 2011; Grover & Pea, 2013). In this context, the continuing education and professional development of educators should include practical experiences in programming and problem-solving, thus facilitating their competence in teaching these concepts (Bers, 2010; Chen et al., 2017).

In addition, computational thinking can serve as a crucial bridge to close educational gaps and promote digital inclusion in diverse educational settings (Wing, 2006; Grover & Pea, 2013). In particular, it has been observed that the integration of CP into early childhood education can help foster equity in access to fundamental digital skills, allowing students from diverse socioeconomic backgrounds to develop key competencies from an early age (Botički, Pivalica, & Seow, 2018; Enríquez Ramírez, Raluy Herrero, & Vega Sosa, 2021).

At the initial educational levels, there is an increase in proposals that seek to introduce students to the basic structures of sequential programming through technological environments. Several studies show that a computationally focused perspective benefits the development of mathematical reasoning and problem-solving skills (Chen et al., 2017; Diago & Arnau, 2017; Merino et al., 2018; Sáez & Cózar, 2017). Teaching problem-solving using programmable robots shows great potential, as it aligns with the demands and skills of the problem-solving approach proposed by Polya (1945), which highlights the importance of breaking down complex problems into more manageable and usable steps to arrive at a solution.

Therefore, it is imperative to conduct research that analyzes the effects of computational thinking-related activities on the development of mathematical reasoning skills in children. This initiative will not only allow a comprehensive evaluation of the impact of integrating this approach in educational settings, but will also facilitate more efficient planning of the educational curriculum. In addition, it is crucial to consider the contextual variables that can influence the effectiveness of these strategies, such as student motivation, the learning environment, and the quality of available technological resources. This research could contribute significantly to the development of more inclusive and effective education policies, as well as to the creation of evidence-based teaching practices that promote meaningful and lasting learning.

Definition of Computational Thinking

The concept of "Computational Thinking" was introduced by Jeannette M. Wing in 2006, who described it as a form of analytical thinking intimately linked to computer science. Wing explained that computational thinking not only focuses on problem solving and system design, but also facilitates the understanding of human behavior through fundamental principles of computation (Wing, 2006). This approach is crucial in today's digital age, where computer skills are increasingly relevant across multiple disciplines and contexts.

Wing (2008) expandedthedefinitionofcomputationalthinkingbynotingthatitencompassesallphasesinvolved in problemsolving, fromproblemidentificationtoimplementation and evaluation of solutions. This process is handled by information processing tools, thusallowingfor a systematic and logicalapproach. In thissense, computationalthinkingbecomesanessentialcompetenceforthe 21st century, as itfostersskillssuch as criticalthinking, creativity and collaboration.

Support for this perspective is evident in the work of Aho (2012), who emphasized that computational thinking includes all the steps necessary to formulate problems, allowing solutions to be represented in the form of sequences of steps and algorithms. This ability to break down complex problems into more manageable components is critical in a variety of areas, from programming and engineering to social sciences and education. In this way, computational thinking is established as a powerful tool for defining, understanding, and solving problems using computer concepts (Bers et al., 2019).

Brennan and Resnick (2012) broke down the concept of computational thinking into three interrelated dimensions: (a) computational concepts, such as iteration, parallelism, and abstraction, which are essential to programming; (b) computational practices, which are the procedures followed when developing a program, such as debugging, modifying, and combining jobs; and (c) computational perspectives, which refer to the perceptions designers have about the world and themselves, which influences their process of creation and problem-solving.

This breakdown has been key in the development of programming tools like Scratch, which is widely used in education to introduce students to programming concepts in an accessible and fun way. However, some authors point out that, although computational thinking has its roots in computer science, it is a form of thinking applicable to any field or area of learning, allowing students to develop transferable skills that are valuable in a wide variety of contexts (Aho, 2012; Yadav et al., 2017).

II. METHODOLOGY

This research adopted a qualitative methodological approach based on a systematic literature review, following the guidelines established by Piantanida and Garman (1999) and Savin-Baden and Major (2013). The main objective was to evaluate the positive effects of the implementation of gamification strategies through the use of Information and Communication Technologies (ICT) in preschool education. To this end, documents from scientific journals indexed in Scielo, SCOPUS and Google Scholar were selected, which represent the main sources of academic literature in the area. The selection of the documents was made in accordance with the PRISMA guidelines of the University of York (2015), which promote transparency and replicability in systematicreviews.

The selection criteria considered were the following:

- Temporality: Publications made in the last 9 years (2015-2024) were included to reflect the recent evolution of computational thinking in preschool education, thus ensuring that the review is aligned with current trends in educational research.

- Thematic relevance: The relevance of the content in relation to the research topic was evaluated, ensuring that the documents effectively addressed the intersection between gamification, ICT and preschool education.

- Language: Articles published in English or Spanish were included, facilitating an inclusive review of the relevant literature in the field.

The search terms used were: "computational thinking in preschoolers" AND "gamification strategies in early childhood education" AND "ICT in preschool education" AND "digital literacy in young children" AND "digital competences in childhood". We reviewed studies published between 2015 and 2024, applying inclusion criteria that included empirical studies, theoretical reviews, and relevant case studies. As a result, a total of 17 articles were selected for this review.

Selection of Articles
The selection process was carried out in three rigorous phases:

Initial search: At this stage, documents that did not meet the established temporal criteria (last 15 years) and those that were not written in English or Spanish were excluded, thus guaranteeing the inclusion of relevant and accessible literature.

Second phase: Only open access articles that were directly related to the preschool educational context were selected, which allowed the number of documents to be reduced to 34. These articles were processed by using Mendeley to eliminate duplicates and facilitate the handling of the bibliography.

Final stage: After applying the previously established selection criteria, a final set of 17 articles was obtained, which served as the basis for the systematic review.

An exploratory systematic review was carried out with the purpose of identifying advances in the study of computational thinking in preschool education. The research question asked was: What research was carried out on computational thinking in the context of early childhood education? This systematic review not only made it possible to identify the most relevant research and emerging trends, but also helped to reveal knowledge gaps in the area. Finally, the systematic review summarized and synthesized the information obtained from the primary articles, offering a comprehensive perspective on the impact of gamification strategies and ICT on the formation of digital competencies in childhood.

III. RESULTS

NUMBER	COUNTRY	BIBLIOGRAPHIC REFERENCE	OBJECTIVE	METHODOLOGY	KEY FINDINGS

1	USA	Strawhacker, A., Lee, M., & Bers, M.U. (2018). Teaching Tools, Teachers' Rules: Exploring the Impact of Teaching Styles on Young Children's Programming Knowledge in ScratchJr. International Journal of Technology and Design Education.	Analyze how teaching styles (guided vs. free) influence programming learning in young children with ScratchJr.	Experimental study with 60 children (5-7 years old), distributed according to the teacher's teaching style.	Guided teaching promotes a greater understanding of basic programming concepts, providing structure and support.
2	USA	Resnick, M., et al. (2019). Scratch: Programming for All. Communications of the ACM.	Describe Scratch and its impact on learning computational thinking.	Descriptive study and review of use cases.	Scratch promotes creativity and collaboration, making programming accessible and fun even at young ages.
3	USA	Bers, M.U., et al. (2014). Computational Thinking and Tinkering: Exploration of an Early Childhood Robotics Curriculum. Computers & Education.	To evaluate a robotics curriculum in the development of computational thinking in preschoolers.	Quasi-experimental with 100 children (4-6 years) for 12 weeks.	Improvements in problem-solving and sequential thinking; Robotics supports key cognitive skills.
4	USA	Kazakoff, E.R., & Bers, M.U. (2012). Programming in a Robotics Context in the Kindergarten Classroom: The Impact on Sequencing Skills. Journal of Educational Multimedia and Hypermedia.	To analyze the impact of robotics programming on sequencing skills in kindergarten.	Experimental study with control and experimental group.	The use of robotics significantly improves sequencing and logical thinking.
5	Singapore	Sullivan, A., & Bers, M.U. (2018). Dancing Robots: Integrating Art, Music, and Robotics in Singapore's Early Childhood Centers. International Journal of Technology and Design Education.	Explore the integration of art, music, and robotics in preschoolers.	Case study in 5 schools.	Increased creativity and understanding of robotics; Interdisciplinary integration enriches the teaching of computational thinking.

6	Colombia	García Angarita, M., et al. (2021). A Proposal for the Development of Computational Thinking in Children and Youth. Ibero-American Journal of Technology in Education and Education in Technology, 30.	Submit a proposal to develop computational thinking from the age of 5.	Recreational activities in the "Saturdays in the Family" project.	Improvements in exercise resolution and teamwork.
7	Spain	García-Valcárcel, A., & Caballero-González, Y.A. (2019). Robotics to develop computational thinking in Early Childhood Education. Comunicar, 27(59), 49-58.	To evaluate the impact of educational robotics in preschool.	131 children (3-6 years old).	Robotics develops digital competencies and programming skills from an early stage.
8	Spain	Ortega-Ruipérez, B., & Asensio Brouard, M.M. (2018). DIY robotics: computational thinking to improve problem solving. RLTE, 17(2), 129-142.	Propose a robotics maker strategy for problem solving.	Course with 38 high school students.	It encourages abstraction, algorithmy, and transfer to real contexts.
9	Spain	Moreno y Román (2016). Code to Learn: Where Does It Belong in the K-12 Curriculum?	Evaluate the impact of Scratch in different areas.	129 students (2nd-6th grade).	Greater learning in social studies than in mathematics.
10	Spain	Caballero-González, Y. (2020). Strengthening computational thinking and social skills through educational robotics.	Analyze digital skills and sequencing with Bee-Bot®.	40 initial students.	Improvements in sequencing and spatial orientation.
11	Spain	Cervera, N., et al. (2020). The acquisition of computational thinking through mentoring. Education Sciences, 10(8).	Evaluate mentoring with Bee-Bot in young children.	Case study with 2nd grade (7-8 years) and 4th grade mentors.	Mentoring increases motivation, cooperation, and computational thinking.
12	Colombia	Robledo, C., et al. (2023). The teaching of computational thinking and its	To analyze the effects of computational thinking on	Experimental trial with 30 children.	Significant improvements in executive functions.

		effects on children's executive functions. EIA Journal, 21(42).	executive functions.		
13	Panama	Vásquez, H.M., et al. (2023). Computational Thinking: A Twenty-First Century Competency. RLO, 4(9).	Review literature on computational thinking as a key competency.	Systematic review in Scopus.	It is essential to integrate it into all educational levels.
14	Spain	Sepúlveda-Durán, C.M., et al. (2023). Impact of the "Unplugged Music" program.	To evaluate the impact of a music program on computational thinking.	Quasi-experimental with experimental and control groups.	Computational thinking increases, especially in struggling students and in rural areas.
15	Spain	Campollo-Urkiza, A. (2023). Musical program for unplugged computational thinking in early childhood education.	Develop computational thinking with musical activities in 3-year-olds.	Qualitative study in 2 classrooms in Madrid.	Improves spatial reasoning, logical thinking and motor skills.
16	USA	Robinson, L.E., et al. (2016). Effect of the children’s health activity motor program on motor skills and self-regulation in head start preschoolers. Frontiers in Public Health, 4, 173.	To evaluate the impact of motor programs in preschoolers.	Experimental trial.	Improves motor skills and self-regulation.
17	Spain	Moreno-León, J., et al. (2015). Dr. Scratch: automatic analysis of Scratch projects. RED, 46.	Evaluate the usefulness of Dr. Scratch to promote computational thinking.	Case study with 109 students (10-14 years old).	Scratch contributes to the development of computational thinking, although it depends on the context.

The distribution of studies by country shows a varied representation in the field of computational thinking

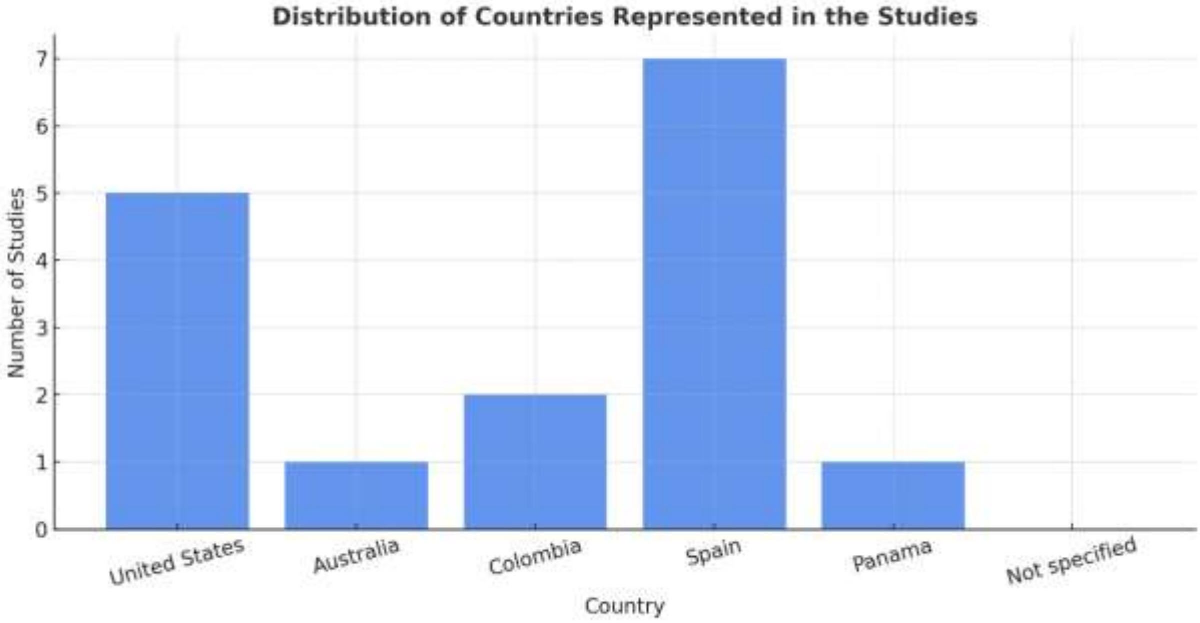

Figure 1. *Distribution of countries represented in the studies*

Spain stands out with a total of seven studies, which represents the highest number among all countries. This fact reflects a notable focus on educational research in Spain, consolidating it as the region with the greatest activity in this field in Europe.
For its part, the United States continues with four studies, positioning itself as the second country with the largest number of investigations. This number indicates significant investment and attention in technology education and computational thinking in North America.

In South America, Colombia presents two studies, demonstrating moderate interest in the development of computational thinking and robotics. Although its share is smaller compared to Spain and the United States, it represents an important contribution to the region.

Finally, Australia and Panama have one studio each. This underrepresentation suggests that research in these countries is relatively limited compared to others, which could be related to a lower focus on this specific domain.

Consequently, the distribution reveals that Spain and the United States are the leaders in research on computational thinking and robotics, with Spain dominating in Europe and the United States in North America. Colombia shows a significant share in South America, while Australia and Panama have a smaller representation in Oceania and Central America, respectively. The category of unspecified information highlights the need to improve the accuracy of data collection on the geographical location of studies.

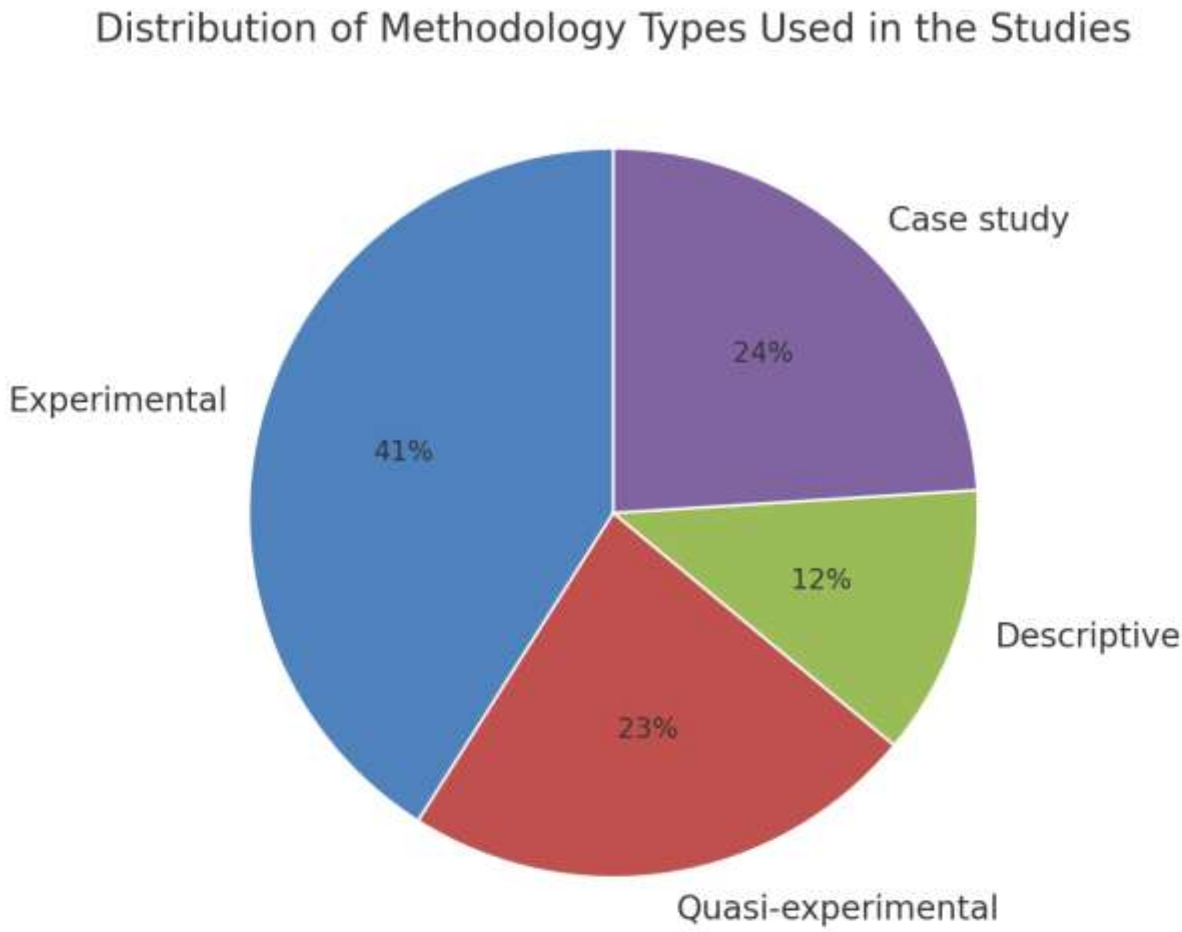

Figure 2. *Distribution of type of methodology used in the studies*

The distribution of studies on computational thinking in preschool education shows a diverse methodological panorama, reflecting a comprehensive approach to research in this emerging field. Experimental studies dominate the sample with 41.18%, highlighting a strong inclination towards the rigorous evaluation of specific interventions designed to introduce computational thinking in preschool contexts. These studies allow us to establish causal relationships between the implementation of educational strategies and the results observed in children, providing solid evidence on the effectiveness of these methodologies.

The methodological distribution observed in studies on computational thinking in preschool education reflects a rigorous approach, with a clear preference for experimental and quasi-experimental methods that allow objectively validating the effectiveness of pedagogical interventions. The predominance of experimental studies indicates a considerable effort to obtain empirical and controlled evidence on how these strategies impact the development of cognitive skills in children, while quasi-experimental studies complement this panorama by situating research in real educational contexts, where the control of variables is not so strict.

The importance of quasi-experimental studies in this field lies in the fact that they allow us to examine how computational thinking tools are implemented in everyday conditions, which is particularly relevant in preschool education, characterized by its variability and lower formal structure compared to other educational levels. These studies offer a more applicable view of pedagogical interventions, allowing researchers and teachers to gain insight into the transfer of skills from laboratories or controlled contexts to real educational scenarios.

On the other hand, descriptive studies, although they represent a smaller portion of the sample (11.76%), are essential to provide an initial contextual understanding. While these studies do not generate direct interventions, they document in detail how computational thinking is being implemented in preschool classrooms and identify recurring patterns and challenges that can guide more robust experimental research. The descriptive information gained about student context, interactions, and behaviors provides a solid basis for hypothesis formulation and the design of more rigorous studies in the future.

Case studies, which make up 23.53% of the sample, are equally valuable, as they provide an in-depth understanding of specific situations. These studies allow for a detailed analysis of how computational thinking strategies are implemented in specific contexts, revealing not only the results, but also the pedagogical processes and particular challenges faced by teachers and students. The qualitative richness of the case studies allows us to explore variations in implementation that may not be captured by the most controlled and generalizable methods. The methodological variety observed suggests that the field of computational thinking in preschool education is moving towards a comprehensive approach that combines the need for rigorous empirical evidence with the detailed exploration of specific educational contexts. This combination of experimental, quasi-experimental, descriptive and case studies allows us to obtain a more complete and nuanced view of how these pedagogical strategies work in practice.

IV. DISCUSSION

Computational thinking (CP) has gained a prominent place in preschool education, particularly in the United States, where innovative pedagogical programs and approaches have been developed to introduce young children to logic and problem-solving through the use of technological tools such as programming and robotics. Recent research has shown that children at an early age can acquire foundational competencies in logical reasoning, sequencing, and planning through activities designed to foster these skills. This advance has led to a growing interest in integrating computational thinking into educational curricula from childhood, aligning with the global trends observed in countries such as Colombia, Spain and Panama, where the incorporation of these skills in school environments is also promoted.

In the United States, a variety of methodological approaches have been developed to teach computational thinking in the early stages of education. For example, Bers et al. (2014) demonstrated that the implementation of educational robotics programs at the preschool level, such as TangibleK, not only supports the development of computational thinking, but also improves skills such as problem-solving, creativity, and collaboration. These programs integrate "tinkering" and design activities, which allow children to work with tangible tools that make abstract thinking visible. In addition, this approach promotes the active and meaningful participation of students in their own learning process, aligningwithconstructivistpedagogy.

As the experiences of the United States are compared with those of other countries such as Spain and Colombia, key differences emerge in methodological approaches and in the application of computational thinking. In the United States, the focus tends to be more focused on creating learning environments where students interact with technology in a direct way, as seen in programs based on educational robotics and the use of visual programming tools such as ScratchJr. These programs have been designed with the goal of making learning programming accessible to younger children, emphasizing knowledge building throughhands-on, collaborativeexperiences.

In comparison, in Spain, the research of García-Valcárcel Muñoz-Repiso and Caballero-González (2019) also highlights educational robotics, but with a broader focus that includes a greater emphasis on the integration of these tools into the formal curriculum, exploring multiple disciplines. The methodological diversity in Spain ranges from the use of robots in the teaching of mathematical concepts to their application in art education, which suggests a more interdisciplinary approach in the teaching of computational thinking. In addition, studies such as that of Ortega-Ruipérez and Asensio Brouard (2018) in Spain promote the "do it yourself" (DIY) philosophy, where students not only learn to use robots and technological tools, but also actively participate in their construction and modification, encouraging deeper and more personal learning.

In Colombia, on the other hand, studies by García Angarita et al. (2021) and Robledo Castro et al. (2023) show how computational thinking approaches have adapted to local sociocultural realities. For example, the "Saturdays in the Family" program not only seeks to teach technical skills to students, but also involves families in the educational process, encouraging socialization and teamwork in low-resource contexts. This culturally adapted approach has been shown to be effective in improving problem-solving and other cognitive competencies in participating children, highlighting the importance of considering specific contexts when designing educational interventions.

A common feature in the approaches of the United States, Spain, and Colombia is the recognition of the potential of computational thinking to develop general cognitive skills, beyond simply learning programming. In both the United States and Colombia, studies have revealed that computational thinking can positively influence students' executive functions, such as working memory and planning, as highlighted by Robledo Castro et al. (2023) and Bers et al. (2014). These findings underscore that computational thinking not only has intrinsic value for learning technology, but can also contribute to an overall improvement in cognitive skills needed for academic success in a varietyofareas.

In Panama, Vásquez Acevedo et al. (2023) highlighted the importance of integrating computational thinking as a key competence in twenty-first-century education. This study, based on a systematic review of the literature, argues that computational thinking should be a transversal skill, similar to literacy or mathematics, preparing students for the challenges of the digital society. This approach is aligned with the proposals of several researchers in the United States, who see computational thinking as an essential competence for active participation in the modern technological world.

The comparison between the approaches in the United States, Spain and Colombia shows a convergence around the importance of computational thinking in early childhood education, although with notable differences in terms of methodology and implementation. While in the United States there is a tendency to prioritize direct interaction with technology through robotics and visual programming, in Spain there is a greater interdisciplinary and methodological diversity, and in Colombia there is evidence of a more specific adaptation to the social and cultural context. These differences reflect how computational thinking, while a globally relevant competency, requires personalized and culturally sensitive approaches for its effective integration into the education systems of different countries.

Analysis of Tools and Methodologies for the Development of Computational Thinking
Guided and Free Teaching: Scratch and ScratchJr
In the realm of technologies for teaching computational thinking, platforms such as Scratch and ScratchJr have had a significant impact. These tools, designed for children, make it easier to understand basic programming concepts by creating interactive projects. Studies such as that of Strawhacker, Lee, and Bers (2018) have shown that, in a structured environment, children between 5 and 7 years old who use ScratchJr with more guided teaching tend to develop a better understanding of sequencing concepts and algorithms. This finding underscores the importance of providing adequate pedagogical support duringthelearningprocess.

Comparing free and guided teaching on these platforms reveals that while autonomous learning promotes creativity, structured instruction is crucial for establishing strong foundations in computational thinking. In countries like the United States, these approaches are being widely adopted in primary education curricula, not only to teach programming, but also to foster skills such as problem-solving and logical thinking.

Educational Robotics: International Approaches
Educational robotics is another effective tool that has been explored in several countries to teach computational thinking from an early age. In Spain, the study by García-Valcárcel Muñoz-Repiso and Caballero-González (2019) showed how the integration of robots in the classroom can significantly improve programming skills and foster meaningful learning in children aged 3 to 6 years. Children who participated in robotics activities developed key cognitive competencies, such as sequencing and problem-solving, which is critical in computational thinking.

Likewise, in Singapore, the study by Sullivan and Bers (2018) highlighted an interdisciplinary approach that combined robotics with art and music. This approach not only stimulated computational competencies, but also promoted students' creativity and interest. These results suggest that educational robotics, when combined with other disciplines, may offer a more comprehensive approach tolearningtechnologicalskills.

Zhorai: Artificial Intelligence and Adaptive Learning
The use of Zhorai, an AI-powered platform, has also been examined as a tool to facilitate the learning of computational thinking in young children. In studies conducted by Wang et al. (2021), it was observed that Zhorai offers a personalized learning experience, adapting the pace of lessons to each child's responses. This type of verbal and personalized interaction is especially useful for children at young ages who have not yet developed advanced reading skills, making the tool inclusive and accessible.

Unlike Scratch or educational robotics, Zhorai allows children to interact in a conversational way with a digital avatar that guides them through programming concepts. While this approach has clear advantages in terms of customization and accessibility, it's important to note that platforms like Scratch and robotics promote greater visual and kinesthetic interaction, which is also essential for certaintypesoflearning.

Mentoring and Collaboration Approaches

Regarding collaborative teaching, research carried out in Spain by Cervera et al. (2020) highlights the effectiveness of mentoring models among students. In this study, older students acted as mentors to their younger peers, helping them gain computational thinking skills through programming and robotic activities. This model not only facilitated learning, but also encouraged teamwork and collaboration, which is crucial for the development of soft skills in addition to technological competencies.

Emerging Issues in the Teaching of Computational Thinking

Early Age and the Capacity for Abstraction:

One of the most interesting points that emerge from the studies is the ability of preschoolers to understand and apply programming and computational thinking concepts, which have traditionally been associated with older ages. Both the study by Bers et al. (2014) and Kazakoff and Bers (2012) indicate that, through tangible tools such as robotics and visual programs such as ScratchJr, children are able to develop sequencing and problem-solving skills. These findings suggest that abstraction, a cognitive ability critical to computational thinking, may begin to develop much earlierthanpreviouslythought.

Role of Play and Creativity in Learning:

Another outstanding issue is the role of play and creativity in the teaching of computational thinking. Studies by Sullivan and Bers (2018) underline that the integration of creative elements, such as art and music, and the use of playful tools such as robots and visual programs, not only facilitate the learning of technical concepts, but also foster creativity and intrinsic motivation in children. This suggests that computational thinking should not be taught in isolation, but in combination with other creative disciplines tomaximizeeducationalimpact.

Teaching Styles and Pedagogical Effectiveness:

The study by Strawhacker, Lee, and Bers (2018) highlights the importance of teaching styles in the effectiveness of computational thinking learning. The comparison between guided teaching and free teaching reveals that children tend to benefit more from a pedagogical structure that provides them with guidance as they explore complex concepts. This raises questions about the optimal balance between creative freedom and structure in teaching programming and computational thinking at anearlyage.

Cultural Contexts and Curricular Adaptation:

The study by Sullivan and Bers (2018) in Singapore introduces a crucial perspective on how cultural contexts influence the implementation and effectiveness of educational tools. Adapting the curriculum to incorporate local cultural aspects, such as the integration of artistic disciplines, demonstrates that not all approaches are equally effective in all settings. This suggests that curriculum designers should consider cultural and social particularities when developing computational thinking programs for preschoolers, ensuring that they are relevant and accessible to students in diverse contexts.

Long-Term Impact on Cognitive Development:

An underlying issue, although not always directly addressed in these studies, is the long-term impact of learning computational thinking in early childhood. Although the studies reviewed show immediate improvements in sequencing, problem-solving, and logical thinking skills, it remains to be explored how these skills carry over to later stages of education and whether they provide a lasting cognitive advantage. This opens up an important direction for future research that could investigate the continuity and progression of computational thinking development from preschool to higher education.

Considerations

When analyzing the differences and similarities between studies on computational thinking in preschoolers, it is evident that research in this field is in an emerging phase of exploration and development. Although current tools and approaches have shown effectiveness in introducing children to key concepts of programming, the diversity in methodologies, educational contexts, and outcomes underscores the need for a more personalized and adaptive pedagogical approach.

First, it is crucial to recognize the importance of pedagogical styles in teaching computational thinking. Different studies have used various didactic strategies, from game-based learning to the integration of practical activities with robotic technology, each with its own advantages and limitations. This variety suggests that there is no one-size-fits-all approach that works for all children and that it is critical to tailor methodologies to the individual needs of students. A more personalized approach could not only improve understanding of computational concepts, but also increase children's motivation and interest in learning.

In addition, integrating creative disciplines, such as music, art, and storytelling, into the teaching of computational thinking can offer a more holistic approach that addresses both technical and creative skills. Some studies suggest that combining programming with creative activities not only makes it easier to understand abstract concepts, but

also encourages creative expression and critical thinking. This is especially relevant in preschool education, where learning through play and creativity is fundamental for the integral development of children.
Finally, the adaptation of educational programs to the cultural particularities of students is another key aspect that emerges from the comparison of these studies. Research has shown that cultural contexts can significantly influence how children learn and apply computational thinking. It is therefore essential that teaching programmes are culturally sensitive and that they are adapted to the realities and values of the communities where they are implemented. This will not only ensure greater relevance and acceptance of the programs, but will also contribute to equity in access to technology education.

Prospects for the Future
While these studies have established a solid foundation for understanding how computational thinking can be taught to preschoolers, they also raise a number of questions that will need to be addressed in future research.
One of the areas that requires the most attention is the long-term impact of early childhood computational thinking instruction. While there are indications that early exposure to these concepts can improve cognitive and problem-solving skills, longitudinal studies are needed to explore how these skills develop and transfer to other areas of knowledge over time.
Another important question is how to find the right balance between pedagogical structure and creativity in the teaching of computational thinking. While it's essential to provide children with a structure that allows them to understand the basic principles of programming, it's also important to give them the freedom to explore and create independently. The challenge lies in designing curricula that strike this balance and allow children to develop both technical and creative skills.
Finally, the adaptability of curricula to different cultural contexts is a question that deserves further investigation. As computational thinking becomes an increasingly valued skill around the world, it's critical that educational programs are flexible enough to be effective in a variety of cultural contexts. This not only involves translating materials into different languages, but also adapting examples, metaphors, and activities to students' cultural experiences.
Addressing these issues will not only improve the effectiveness of early childhood computational thinking instruction, but also maximize its potential to develop skills that will be critical in students' educational and professional futures. In addition, it will contribute to a better understanding of how to prepare children for an increasingly digital world, ensuring that everyone has the opportunity to become creators and not just consumers of technology.

One of the recommendations for future research is the use of mixed methods that integrate both quantitative and qualitative approaches. This type of approach would allow not only to measure the impact of interventions in terms of academic results, but also to understand the teaching and learning processes that underlie these results. In addition, it is crucial that experimental studies consider more contextual variables, such as socioeconomic environment and access to technology, as these factors can influence the success of computational thinking implementation.

Another promising line for future research is the exploration of the longitudinal impact of computational thinking interventions on children's cognitive and academic development. So far, most studies have focused on short-term outcomes, but there is a need to assess how learning these skills in the early years of life affects future performance in areas such as problem-solving, logical thinking, and collaborative work.

CONCLUSION

Research around computational thinking in preschool education has underscored the growing importance of integrating these skills from the early stages of academic life. Computational thinking is not only limited to programming or the use of technologies, but encompasses a set of critical skills such as sequencing, logic, and problem solving, which are fundamental for the comprehensive training of students in an increasingly digital-oriented world.
Early implementation of computational thinking allows children to develop a structured and methodical way of thinking, which is essential not only for computer science, but for any area of knowledge. By cultivating these skills from an early age, students gain a solid foundation that will enable them to face and solve problems efficiently in various disciplines throughout their lives.
The studies reviewed show that computational thinking has the potential to transform education by encouraging a more active and creative approach to learning. When combined with innovative pedagogical approaches and appropriate technological tools, it is possible not only to improve students' technical competencies, but also to strengthen their ability to think critically and adapt to complex challenges. The diversity of methodological approaches observed in different countries, such as Colombia, Spain and Panama, reflects the need to adapt these

educational strategies to specific contexts in order to maximize their effectiveness. In addition, the relevance of combining computational thinking with other disciplines and creative approaches has been identified, which not only facilitates technical learning, but also promotes creativity and intrinsic motivation in students.
Taken together, these findings underscore the importance of continuing to research and develop educational approaches that integrate computational thinking effectively into the curriculum, thereby preparing students for the challenges of an increasingly digital and globalized society. International collaboration and cultural adaptation will be key to advancing this educational mission.

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