Revista Científica Interdisciplinaria Investigación y Saberes
2025, Vol. 15, No. 3 e-ISSN: 1390-8146
Published by: Universidad Técnica Luis Vargas Torres

Computational Thinking in Elementary Education: A Review of Its Teaching and Benefits for Cognitive Development

Pensamiento computacional en la educación básica: una revisión sobre su enseñanza y beneficios en el desarrollo cognitivo

Nancy Patricia Vásconez Panata
Magíster en Educación, investigadora independiente. Guaranda
nancy.vasconez90@gmail.com, https://orcid.org/0009-0008-1069-1278

Luz América Panata Villacís
Magíster en Educación, Unidad Educativa Celso Augusto Rodríguez, Cumandá
america.panata64@gmail.com, https://orcid.org/0009-0008-8027-009X

Carlos Bayardo Toapanta Chaguaro
Magíster en Educación, Unidad Educativa Galo Plaza Lasso, Echeandía
carlostoapantachaguaro@gmail.com, https://orcid.org/0009-6733-7007

Marcia Elizabeth Samaniego Alarcón
Magíster en Educación, Unidad Educativa Adolfo Páez, Echeandía
goalarco@gmail.com, https://orcid.org/0009-0003-9990-3014

Received 2025-03-21
Revised 2025-04-21
Published 2025-08-05
Corresponding Author
nancy.vasconez90@gmail.com
Pages: 1-12
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Abstract

Computational thinking has emerged as a fundamental competency in basic education, driven by the challenges of the 21st century and the growing need to develop students with strong digital and cognitive skills. The objective of this literature review was to analyze approaches, methodologies, and benefits associated with the implementation of computational thinking in Latin American schools. A qualitative documentary research was conducted through an integrative review of ten scientific articles published between 2017 and 2024. The data was organized through analysis sheets, and selection criteria such as thematic relevance, accessibility, and academic quality were applied. The results showed that

How to cite this article (APA): Vásconez, N., Panata, L., Toapanta, C., Samaniego, M. (2025) Computational Thinking in Elementary Education: A Review of Its Teaching and Benefits for Cognitive Development, *Revista Científica Interdisciplinaria Investigación y Saberes,* 15 (3) 1-12

computational thinking promotes the development of logical reasoning, creativity, and problem-solving. Furthermore, its teaching through tools such as block programming, educational robotics, and gamified environments has proven effective in the school context. The discussion highlighted the need to strengthen teacher training and public policies that integrate these skills into curricula. The conclusion is that computational thinking not only enhances cognitive skills but should be promoted as a key element of educational innovation in Latin America.

Keywords: Computational thinking; basic education; educational innovation; 21st-century skills; educational programming; literature review.

Resumen

El pensamiento computacional ha emergido como una competencia fundamental en la educación básica, impulsada por los retos del siglo XXI y la creciente necesidad de formar estudiantes con habilidades digitales y cognitivas sólidas. El objetivo de esta revisión bibliográfica fue analizar enfoques, metodologías y beneficios asociados a la implementación del pensamiento computacional en escuelas de América Latina. Se desarrolló una investigación cualitativa de tipo documental, mediante revisión integrativa de diez artículos científicos publicados entre 2017 y 2024. Los datos se organizaron a través de fichas de análisis, y se aplicaron criterios de selección como pertinencia temática, accesibilidad y calidad académica. Los resultados evidenciaron que el pensamiento computacional favorece el desarrollo del razonamiento lógico, la creatividad y la resolución de problemas. Además, su enseñanza a través de herramientas como la programación por bloques, la robótica educativa y los entornos gamificados ha demostrado ser efectiva en el contexto escolar. La discusión resaltó la necesidad de fortalecer la formación docente y las políticas públicas que integren estas habilidades en los planes curriculares. Se concluye que el pensamiento computacional no solo

potencia habilidades cognitivas, sino que debe ser promovido como un eje clave en la innovación educativa en América Latina.
Palabras clave: Pensamiento computacional; educación básica; innovación educativa; habilidades del siglo XXI; programación educativa; revisión bibliográfica.

Introduction

Computational thinking has emerged as an essential skill for the 21st century, encompassing not only technical skills associated with computer science, but also key cognitive processes such as problem solving, logical thinking, abstraction, and structured analysis. Its integration into basic education has been driven by the need to prepare citizens for a digitally and technologically advanced society (Wing, 2006; Voogt et al., 2015). Latin America has not been immune to this movement, developing various strategies to incorporate computational thinking into the school curriculum, albeit with challenges related to infrastructure, teacher training, and pedagogical adaptation.

Basic education represents a strategic space for the early development of complex cognitive skills. Teaching computational thinking at this level can have a significant impact on areas such as mathematical understanding, logic, language, and creativity, as well as fostering autonomy and collaborative problem solving (Román-González et al., 2017). However, the diversity of curricular and implementation approaches in Latin American countries highlights the need to systematically review existing practices and programs.

The purpose of this article is to conduct a literature review of recent studies on the teaching of computational thinking in basic education, with an emphasis on its benefits for cognitive development. To this end, research published between 2017 and 2024 will be analyzed, selected for its relevance, methodological rigor, and pertinence to the Latin American context. Through this review, we seek to identify the most effective pedagogical strategies, the main implementation challenges, and opportunities for improvement in teacher training and curriculum design.

The work will also examine how computational thinking is conceptualized in educational literature, differentiating between instrumental and pedagogical approaches. This distinction is key to understanding the depth with which it is integrated into the classroom: from the use of programming languages such as Scratch to active methodologies that link it to interdisciplinary projects (Lye & Koh, 2014). International evidence also suggests that a critical appropriation of computational thinking requires rethinking the role of schools in relation to digital culture, moving towards comprehensive literacy that includes ethical, social, and cognitive components.

This article aims to provide a reflective and documented view of the role of computational thinking in basic education in Latin America, considering not only the observable cognitive benefits, but also the institutional conditions necessary for its effective and equitable development.

Methodology

This study is part of a qualitative, documentary, and descriptive research project focused on reviewing and analyzing academic sources related to teaching computational thinking in elementary education and its benefits for cognitive development. This methodology allows us to systematize and understand the current state of knowledge, identify pedagogical trends, and establish relationships between theories, practices, and empirical results.

Source selection criteria

Ten scientific articles published between 2017 and 2024 in indexed, peer-reviewed journals were selected. The inclusion criteria were:

Publications in Spanish or English.

Studies applied to basic or primary education.

Research focused on the teaching of computational thinking or the evaluation of its cognitive impact.

Studies conducted in Latin American countries or of comparative international utility.

Full access to content, with DOI or verified link available.

Duplicate documents, non-academic sources (blogs, Wikipedia, etc.), and articles focused exclusively on higher education levels were excluded.

Data sources

The information was collected through systematic searches in recognized academic databases, such as Scopus, Scielo, ERIC, Redalyc, SpringerLink, and Google Scholar, using combined descriptors such as: "computational thinking," "basic education," "cognitive benefits," "skills development," and "teaching programming in primary school."

Techniques and instruments

A bibliographic analysis matrix was used as an instrument to organize the information extracted from the selected articles. This matrix included the following categories:

Authors and year of publication

Country or context of the study

Educational level addressed

Methodology used

Teaching strategies implemented

Results on cognitive benefits

Pedagogical recommendations

Procedure

Systematic search: Searches were conducted during the month of August 2025, applying filters for date, language, and document type.

Exploratory and selective reading: Abstracts, introductions, and conclusions were examined to verify thematic relevance.

Analytical reading: The selected articles were read in full to identify the main findings.

Recording in matrix: Each article was systematized in the designed matrix, which facilitated comparison between studies and subsequent thematic analysis.

Synthesis and interpretation: A comprehensive analysis of the findings was prepared, highlighting common patterns, significant contributions, and gaps in the literature.

Results

Based on the analysis of the 10 selected articles, common patterns were identified in terms of computational thinking (CT) teaching approaches, tools used, and cognitive development benefits. The following matrix summarizes the key information. Table 1 summarizes the main characteristics of the selected articles:

Table 1. *Matrix for analyzing articles on computational thinking*

Autor(es) y año	Nivel educativo	Estrategias empleadas	Beneficios cognitivos destacados	País / Contexto
Quiroz-Vallejo et al. (2021)	Primaria y secundaria	Robótica, Scratch, lógica algorítmica	Mejora en resolución de problemas y pensamiento crítico	México, Colombia
Gutiérrez-Aguilar (2024)	Primaria	Juegos digitales y unplugged coding	Desarrollo de memoria operativa y atención	Perú
Paraskevopoulou-Kollia et al. (2025)	Preescolar y primaria	Secuencias visuales, tangram, storytelling digital	Razonamiento lógico, habilidades narrativas	Revisión internacional
Del Olmo Muñoz et al. (2025)	Primaria	Evaluación multidimensional con rúbricas	Fortalecimiento del metacognición y autonomía	España

Perea (2023)	Primaria	Programación lúdica y bloques	Aumento de creatividad y toma de decisiones	Ecuador
Martínez (2022)	Inicial y primaria	Enfoque transversal en currículo	Mejora de organización mental y pensamiento flexible	Colombia
Silva et al. (2021)	Primaria	App educativas, Bee-Bot	Desarrollo secuencial y atención sostenida	Brasil
Vázquez et al. (2019)	Primaria	Pensamiento computacional transversal	Incremento de razonamiento matemático	Argentina
Tang et al. (2020)	Primaria y secundaria	Evaluación por retos y resolución de algoritmos	Fluidez cognitiva y pensamiento analítico	Revisión global
UNESCO (2024)	Primaria	Marcos de competencias docentes y estudiantiles	Formación integral y habilidades transferibles	Latinoamérica

The results obtained reveal that computational thinking has been implemented mainly at basic education levels, both early childhood and primary, with significant adaptations depending on the context. Tools such as Scratch, Bee-Bot, and educational games have been widely used due to their ease of access and adaptability.

A clear trend is the incorporation of the PC as a cross-curricular strategy, not only in STEM subjects but also in areas such as language and social sciences. This integration has been shown to have a positive impact on higher cognitive functions such as metacognition, problem solving, planning, critical thinking, and working memory (Gutiérrez-Aguilar, 2024; Del Olmo Muñoz et al., 2025).

Research also agrees on the importance of the pedagogical context, the active role of the teacher, and the use of authentic assessments to evaluate computational skills (Tang et al., 2020; UNESCO, 2024). Despite this, challenges such as the lack of specific teacher training, inequality in technological access, and the absence of standardized educational policies are evident.

Overall, the analysis shows that computational thinking in basic education not only contributes to cognitive development but also acts as a catalyst for more innovative, critical, and student-centered teaching.

The findings in the ten articles reviewed highlight a clear trend: computational thinking (CT) is emerging as a key skill for the 21st century in basic education, both in Latin America and globally. Its integration into the curriculum has demonstrated benefits not only in the development of technical skills, but also in cross-cutting competencies such as problem solving, logical thinking, and creativity.

Various studies agree that the incorporation of CT in primary classrooms must be accompanied by active, student-centered methodologies. According to Voogt et al. (2015), the most effective pedagogical strategies for the development of CT involve project-based learning, block programming, and real-world problem solving, which is consistent with the Latin American studies included in this review. The evidence also points to teacher training as a critical factor. Carbonaro et al. (2020) argue that teacher training programs in computational thinking should focus not only on technological tools but also on changing pedagogical mindsets, which remains a challenge in many education systems.

In the Latin American context, there is a growing effort to adapt international experiences to the local environment. According to Guzmán & Páez (2021), initiatives such as the implementation of Scratch or Bee-Bot in rural schools have shown positive results, but have also faced limitations associated with technological infrastructure, teacher training, and resistance to change. UNESCO (2023) has also identified significant gaps in the systematic implementation of computational thinking in national curricula in the region, recommending comprehensive and sustained public policies.

Another aspect highlighted in the discussion is the inclusive approach. Brennan & Resnick (2012) emphasize that computational thinking should not be limited to the field of computer science, but should be expanded to all areas of knowledge as a general way of thinking. This is especially relevant to ensure educational equity in contexts of sociocultural and economic diversity, a priority highlighted in several Latin American studies.

Finally, there is a growing body of academic literature on the subject, indicating a sustained interest in strengthening the theoretical and methodological basis of CT teaching in basic education. However, there is still a need for greater systematization of results, standardized assessment frameworks, and longitudinal validation of the impacts of CT on overall academic performance and the comprehensive development of students.

Conclusions

The analysis of ten scientific studies showed that computational thinking has become an essential cross-curricular skill in basic education. Its integration not only promotes technological skills, but also higher-order cognitive skills such as logical reasoning, creativity, and structured problem solving, benefiting students from the early stages of their education.

The findings reveal that active pedagogical approaches, such as block programming, project-based learning, and gamified environments, favor the development of computational thinking in diverse school contexts. These methods also encourage collaborative learning and student motivation, key elements for a transformative and contextualized education.

One of the challenges identified lies in teacher training, both initial and continuing. The review shows that many Latin American countries still lack solid training programs and sufficient resources to implement computational thinking effectively, which has an impact on the sustainability of the successful experiences recorded in case studies.

Finally, the review highlights the need to design comprehensive education policies that take into account digital infrastructure, teacher training, and the inclusion of computational skills in official curricula. Promoting equity in access to these tools will be key to ensuring that all students, regardless of their context, develop skills commensurate with the challenges of the 21st century.

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