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Computational Thinking Teaching Methodologies for Non-Programmers: Perspectives from Artificial Intelligence and Virtual Environments

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Abstract

Computational thinking (CP) is an essential competence in the digital age, with growing academic interest reflected in a steady increase in publications since 2016. This article examines effective methodologies for teaching computational thinking (CT) to non-programmers, emphasizing the role of artificial intelligence (AI) and virtual environments. A systematic review of major academic databases revealed key strategies, including immersive simulations, gamified learning, and unplugged activities. These methods effectively build both cognitive and technical skills, making CT more accessible. The findings underscore the potential of AI to personalize learning and expand its reach to non-technical disciplines, such as social sciences and art, promoting a more inclusive approach. However, challenges remain, such as the lack of longitudinal studies, the need to consider individual cognitive factors, and implementation in resource-limited contexts. This study proposes pedagogical strategies to maximize the impact of AI in PC teaching, addressing the identified gaps and promoting accessible, ethical and equitable learning.

Keywords: artificial intelligence, methodologies, non-programmers, computational thinking, virtual environments.

Introduction

Computational thinking (CT) is an essential skill in today's digital era, equipping individuals with strategies like abstraction, pattern recognition, and automation to solve complex problems. While traditionally associated with technical fields, CT's applicability to non-technical disciplines is gaining recognition. According to recent analyses, research on CP has grown significantly since 2016, with a notable increase in the number of related publications in 2023 and 2024, reflecting a global interest in this field (Soui & Haddad, 2023; Voskoglou, 2024).

The use of Digital Skills to promote innovation in the field of Computer Science and Information Engineering (CSE) has gained relevance in the 21st century. This is because digital technologies are becoming more sophisticated and are used in a wid-er range of applications. As a result, there is a growing demand for CSE profession-als with skills to use digital technologies to solve complex problems and develop innovative solutions (Young, 1964). In May 2022, the Colombian Ministry of National Educa-tion (MEN) (Chen, 1993) published the Technical Note National Ecosystem for Educational Innovation and Digital Transformation as a proposal to articulate the efforts of the different actors in the Colombian education sector to promote educational innova-tion and digital transformation. This implies the incorporation and appropriation of digital tools, the improvement of learning processes and social mobilization. In this way, the development of digital skills will be promoted in the educational communi-ty, both in students and in teachers and managers, so that they can make the most of the opportunities offered by digital transformation.

Artificial intelligence (AI) has played a transformative role in education by enabling the personalization of learning. Deep learning-based models, such as those that integrate advanced neural networks, have been shown to improve interaction between students and learning platforms, increasing educational outcomes and reducing barriers to access (Gao et al., 2023; Soui & Haddad, 2023). On the other hand, virtual environments, such as simulators and immersive platforms, have been widely adopted to foster creativity and improve learners' self-efficacy, especially in contexts where practical experience is limited (Voskoglou, 2024).

Despite these advances, significant challenges remain. Gender gaps and cultural differences continue to limit the inclusive reach of these technologies. In addition, most research is concentrated in developed countries such as the United States and Spain, while regions with less access to technological resources receive less attention (Gao et al., 2023). This underscores the need for studies that address these inequalities and promote inclusive methodologies for teaching CP.

This context raises key questions about how to effectively combine AI and virtual environments to close learning gaps, especially in underrepresented populations. This work seeks to contribute to the field by identifying effective practices and pointing out areas that require further exploration to democratize access to computational thinking.

Introduction to Computational Thinking

Computational thinking (CP) is a key skill that allows students to develop competencies such as decomposition, pattern recognition, and abstraction, which are necessary to solve complex problems in a digitized world. Its teaching not only improves technical competencies, but also fosters transversal skills applicable to various disciplines (Gao et al., 2023). In addition, recent studies have explored its application in educational contexts with non-technical populations, addressing the challenge of presenting abstract concepts in an accessible and understandable way (Soui & Haddad, 2023).

Computational thinking (CP) enables students to tackle complex problems by decomposing and automating processes. In the educational field, it has been observed that its teaching improves transversal skills such as problem solving and abstraction. In advanced technological contexts, tools such as Scratch and Alice have facilitated PC teaching, while advanced models such as neural networks and AI-based approaches continue to be explored to optimize learning (Hooshyar & Druzdzel, 2024; Martín-Núñez et al., 2023).

Recent studies on the implementation of emerging technologies in education have focused on tools such as augmented reality, smart classrooms, and e-learning platforms. These technologies have shown significant benefits, such as personalizing learning and increasing student interaction. However, they also pose challenges related to accessibility, teacher preparation, and cultural barriers (Cheng, 2019; Martín-Núñez et al., 2023).

In particular, computational thinking (CP) has received increasing attention as an essential competency in digital learning contexts. Recent research highlights innovative approaches to PC teaching, such as serious games, remote labs, and immersive environments, which have been shown to be effective in improving understanding of complex concepts (Kazimoglu et al., 2012; De Lima et al., 2016). In addition, significant gaps have been identified in the inclusion of underrepresented populations, such as women and communities with limited access to technology (Gao et al., 2023).

Below is a table 1 summarizing the knowledge gaps, authors, and key findings in the CP literature review:

Table 1. Knowledge Gaps, Authors and Key Findings of the CP

Author	Title	Key Findings	Knowledge gaps
Cheng, G. (2019)	Exploring factors influencing the acceptance of visual programming environments	Factors that affect the acceptance of visual programming environments, including gender differences.	Need to expand the scope to more diverse populations.
Martín-Núñez, J.L., et al. (2023)	Does intrinsic motivation mediate AI learning and computational thinking?	Intrinsic motivation improves the relationship between AI learning and the PC.	Scarcity of longitudinal studies on the effects of motivation in various contexts.
Kazimoglu, C., et al. (2012)	A serious game for computational thinking	Use of serious games to develop programming skills at an introductory level.	Lack of long-term assessment of the impact on learning with

De Lima, J.P.C., et al. (2016)	Design and implementation of a remote lab	Remote labs that make it easy to teach programming and robotics.	Limited research on the adaptability of these laboratories at different educational levels.
Gao, H., et al. (2023)	Exploring Gender Differences in Computational Thinking	Identification of gender differences in the development of CP in students.	Absence of inclusive education policies to close the gender gap in digital learning.

Source (Own)

Digital skills

According to Gekara, Wu & Xia (2019), digital skills are defined as "a combination of digital mindset (hardware, software, information, systems, security, and innovation), knowledge (theoretical understanding and understanding), competence (cognitive and practical knowledge), and attitude (values and beliefs)." Other definitions of digital skills according to Helsper & Eynon (2013) refer to the functional skills of operating and using technologies for different expressive, social, and imaginative goals, along with the strategic understanding of how Information and Communication Technologies (ICTs) contribute to and are persuaded by business and social aspects.

Helsper & Eynon (2013) research presented four types of digital skills: critical, social, creative and technical skills, because this encompasses the most common types of skills identified in discussions on new literacies Livingstone (2008), the categorisation of which refers to operational areas (creative and technical), strategic understanding of risks and opportunities (social and critical).

Digital skills in the twenty-first century have become an essential part of human life, as the world is increasingly digital, due to the acceleration of factors such as COVID -19 that has enhanced this process, so it is imperative to use technology effectively to succeed both at work and in life. Despite the multiple definitions of digital skills that exist, these fall into two categories: technical skills (specific to the use of computers and other digital devices) which include: Use of a computer or mobile device, Internet access and use, Use of email and other communication tools, Use of software applications, Creation and editing of digital content; and non-technical skills (more general and can be applied to any digital context) such as critical thinking, problem-solving, creativity, collaboration, communication, information literacy, and digital citizenship.

Van Deursen, Courtois & Van Dijk (2010) research identified four categories of digital skills, as follows: 1) Basic or operational skills (necessary to use digital technologies, such as turning a computer on and off, using a keyboard and mouse, surfing the web, among others); 2) Formal skills (corresponding to the ability to use digital tools to create and process information, such as the use of word processing programs, spreadsheets and databases); 3) Informational skills (equivalent to the ability to search, select, evaluate, and use information online effectively and efficiently, as well as the ability to use digital resources to obtain information); and 4) Strategic skills (employing technology to effectively and efficiently set and achieve goals to improve productivity, communication, and collaboration).

More recent research presents the following 5 types of digital skills: 1) Digital literacy: the ability to use digital tools and understand their use Europea (2006) and includes the ability to search, evaluate, use and create information using digital tools Martín & Moreno (2016); 2) Computational thinking: the ability to solve problems using logic and algorithms, has been defined as "Bringing computational thinking to K-12: What does it imply and what is the role of the educational community in computer science?" Ala (2006); 3) Digital communication: the ability to use digital media to interact with other people and transmit information effectively (Helsper & Van Deursen, 2017); 4) Information management: the ability to search, evaluate and effectively use information, essential to address ethical issues in a digitalised world (Van Deursen, Courtois & Van Dijk, 2010) importance of developing critical skills to assess the veracity and reliability of information online; and 5) Digital security: the ability to protect yourself from online threats, such as viruses or cyberattacks, to protect yourself from cyber threats and save your data (Schneier, 2015).

Table 2 presents the results of the systematic review on Digital Skills.

Table 2. Finding of the systematic review of Digital Skills

Author	Results	Remarks
García Peñalvo & Rodríguez	Good level of use of digital tools, learning deficiencies. Positive attitude towards digital learning.	Quantitative population of students in Mexico. Used in educational policies and practices in Mexico.

Martínez (2013)		
Fernández-Sánchez & Aguaded (2016)	Good level of use of digital tools, deficiencies in teaching and learning. Positive attitude towards digital learning with barriers to the use of digital technologies in their teaching.	Mixed population of teachers in Spain. Used in educational policies and practices in Spain.
Coward & Fellows (2018)	Good level of use of digital tools, deficiencies in teaching and learning. Positive attitude towards digital learning with barriers to the use of digital technologies in their teaching.	Quantitative context of Switzerland. There are no significant differences in terms of gender or place of residence. There is a significant difference in creative skills between young people in urban and rural areas.

Note: Research on Digital Skills is still in its early stages.

Digital divide

It corresponds to inequalities in the access, use and exploitation of information and communication technologies (ICTs) between different social groups, it is also defined as the gap between people who have access to digital technology and those who do not. no (Gómez, Alvarado, Martínez & Díaz de León, 2018). This gap can be seen in a number of ways, including access to computers, the internet, and other digital devices. The digital divide can have a significant impact on people's lives, including their ability to get a job, learn new skills and participate in society (Biswal & Arora, 2019). There are many different types of digital divides, including: Geographic divides (people living in rural areas are more likely to lack access to digital technology than those living in urban areas). Economic gaps (people with low incomes are more likely to lack access to digital technology than people with high incomes). Gender gaps (women are more likely to lack access to digital technology than men). Racial gaps (people of color are more likely to lack access to digital technology than white people). Disability gaps (people with disabilities are more likely to lack access to digital technology than people without disabilities).

The digital divide can have a significant impact on people's lives, including their ability to obtain employment, a certain level of digital skills is required today. People who don't have access to digital technology may be at a disadvantage when it comes to applying for jobs. Learn new skills such as coding, graphic design, and web development. People who don't have access to digital technology may be at a disadvantage when trying to learn new skills.

Participate in society by voting, volunteering, and attending community events. People who don't have access to digital technology may be at a disadvantage when it comes to trying to participate in society. The digital divide is a complex problem and does not have an easy solution. However, there are various measures that can be done to address this problem, such as providing free or low-cost access to digital technology, offering training in the use of these tools, and removing barriers to digital participation, such as lack of digital skills or lack of access to the internet are some actions that can make a difference. By focusing on addressing the digital divide, we will make a significant contribution to ensuring that everyone can benefit from the digital revolution.

Artificial Intelligence in Education

Artificial intelligence has proven to be a powerful tool for personalizing educational experiences, as highlighted by Xu et al. (2024), who analyze the impact of AI-based chatbots to improve academic performance and foster critical thinking skills. However, the use of these technologies still faces challenges related to accessibility and equity in diverse contexts (Soui & Haddad, 2023).

Artificial intelligence (AI) is transforming education by providing tools that personalize and improve teaching-learning processes. Intelligent tutoring systems, adaptive learning, and educational analytics are some of the most prominent developments that AI has brought to the educational field. These technologies make it possible to identify individual student needs and adapt content to their learning rhythms and styles (Ayanwale et al., 2022). In addition, AI facilitates automatic assessment and immediate feedback, which are key to effective and continuous learning.

One emerging area is the use of AI in hybrid and remote environments. During the COVID-19 pandemic, these technologies proved to be instrumental in mitigating the limitations of remote learning, especially through tools such as virtual assistants and collaborative platforms (Hsu et al., 2023). However, while AI has shown promise, it also faces challenges, such as biases in algorithms and lack of equitable access to advanced technologies, which disproportionately affect marginalized communities.

AI enhances education by personalizing learning experiences with intelligent tutoring systems and adaptive grading tools. Generative AI further supports engagement through simulated scenarios, empowering students to tackle complex tasks effectively. Addressing ethical challenges like bias and privacy concerns will be crucial for its equitable application (Kong & Abelson, 2019).

The integration of AI raises concerns about academic integrity, particularly the issue of "hallucination," where AI generates biased or inaccurate information. Additionally, ethical challenges related to data privacy and access inequities must be addressed (Kong & Abelson, 2019).

A systematic review examined the impact of AI in science education over a decade, highlighting the advancements and implications of AI technologies in primary and secondary education. The study identified five main categories of technology applications, offering valuable insights into how AI can enhance science teaching and learning. The integration of AI into curricula has been categorized into three orientations: AI-focused, discipline-focused, and a combination of both. An AI-focused curriculum aims to enhance students' AI literacy, equipping them with the competencies necessary to critically evaluate and effectively use AI technologies in various contexts (Jia et al., 2024).

Research into computational thinking education has identified several challenges students face, particularly in discovery learning environments. These challenges include sense-making, process management, and articulation and reflection. Addressing these issues is crucial for effective teaching of complex concepts. Studies have shown that students often encounter difficulties in model development, such as comparing user and expert models, setting initial conditions, and understanding agent interactions. Implementing targeted scaffolds has been effective in guiding students through these complexities (Basu et al., 2016).

The use of generative AI tools to create practice quizzes tailored to specific topics has streamlined the assessment process. Such tools ensure that assessments align with diverse teaching approaches and course requirements, reinforcing students' understanding of complex concepts and improving overall learning outcomes (Cooper, 2023), (Dohn et al., 2022).

Below is a table 3 with recent studies summarizing the knowledge gaps, authors, and key findings in the literature review of AI in education:

Table 3. Knowledge Gaps, Authors, Key Findings of AI in Education

Author	Title	Key Findings	Knowledge gaps
Ayanwale, J., Olufemi, A., & Smith, T. (2022)	Enhancing Computational Thinking through Virtual Environments	AI-powered virtual environments improve creativity and self-efficacy in computational thinking.	Absence of research on its effectiveness in primary and secondary education contexts.
Hsu, T.C., Chang, S.C., & Hung, Y.T. (2023)	How to Learn and Teach Computational Thinking: A Review of Literature	Identify AI-based strategies that facilitate the learning of computational thinking.	It is necessary to evaluate its implementation in multicultural environments and with limited technological resources.
Soui, M., & Haddad, Z. (2023)	Deep Learning-Based Model Using DensNet201 for Enhanced Educational Outcomes	Personalized deep learning models significantly increase academic performance.	Scarcity of longitudinal studies that measure the long-term impact on general skills.
Gao, H., et al. (2023)	Exploring Gender Differences in Computational Thinking	AI helps mitigate gender differences in computational skills through personalized approaches.	Expand studies to validate results in more diverse populations and in different cultural contexts.

Source (Own)

Virtual Environments and Immersive Learning

Virtual environments, such as augmented reality and educational simulators, offer students the opportunity to experience complex scenarios in an immersive way. According to Criollo-C et al. (2024), these technologies are particularly useful in engineering education, where hands-on learning is critical. In addition, Kurilovas & Dagiene (2016) explore how virtual environments can be adapted to specific learning styles using advanced assessment methods.

Virtual environments and immersive learning have transformed education by offering students interactive experiences that simulate real or hypothetical scenarios. These technologies, which include simulators, virtual reality (VR), and augmented reality (AR), facilitate the exploration of complex concepts in safe and practical environments, promoting essential skills such as critical thinking and problem-solving (De Lima et al., 2016).

A distinctive feature of immersive environments is their adaptability to different learning styles, allowing the customization of resources according to the specific needs of students. For example, VR-based gamified platforms have proven to be highly effective in improving knowledge retention, making learning more engaging and motivating. However, these technologies face significant challenges, such as high device costs and access limitations in under-resourced communities (Kazimoglu et al., 2012; Cheng, 2019).

Despite these barriers, technological advances are facilitating the integration of immersive environments at various educational levels. An exemplary case is the use of remote laboratories, designed to support the teaching of programming and robotics through accessible interfaces. These platforms not only expand access to technical education, but also promote practical skills in a controlled environment (De Lima et al., 2016).

Likewise, serious games based on virtual environments have established themselves as effective tools to develop programming and computational thinking skills. These gamified strategies increase student motivation and improve their learning outcomes. However, its sustained impact over time needs to be further investigated (Kazimoglu et al., 2012). On the other hand, the combination of tools such as Moodle and Scratch has proven to be an efficient solution for teaching computational thinking at a distance, especially in contexts where face-to-face learning is not feasible. However, comparative evidence on the effectiveness of these methodologies remains scarce (Marcelino et al., 2018).

Finally, factors such as technological familiarity and gender differences have a significant impact on the acceptance and use of these technologies in the educational field. This fact highlights the importance of considering sociocultural variables in their implementation, as well as the need to carry out studies in diverse populations to ensure the universal effectiveness of these tools (Cheng, 2019).

Methods for Teaching Computational Thinking

Teaching computational thinking (CT) effectively, especially to non-programmers in virtual environments, involves various strategies tailored to engage learners and foster understanding.

Decomposition: Decomposition entails breaking down complex problems into smaller, manageable parts, making them easier to analyze and solve. Educators can use interactive tools in virtual environments to help students identify key problem components and map out resolution steps. Techniques such as flowcharts and diagrams not only visualize the problem's structure but also encourage collaborative efforts (Zitouniatis et al., 2023).

Pattern Recognition: Pattern recognition helps learners identify similarities and trends within problems or datasets, enhancing algorithmic thinking. For instance, virtual simulations or educational games provide datasets that students can analyze to discover patterns aiding problem-solving (Kale et al., 2018).

Abstraction: Abstraction focuses on filtering out unnecessary details while emphasizing relevant information, crucial for effective problem-solving. Virtual environments can simulate scenarios where students practice isolating essential details to build generalized solutions applicable to various contexts (Kale et al., 2018).

Algorithm Development: Developing algorithms is a fundamental part of CT, as it involves crafting logical sequences of steps to address specific problems. Virtual platforms with coding environments enable students to write, test, and refine algorithms, supported by interactive feedback mechanisms (Huang et al., 2009).

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Use of Technological Tools: Incorporating technological tools into education can enhance engagement and understanding. Platforms such as Scratch and Blockly allow students to explore programming concepts interactively, making the learning process both visual and practical (Kong & Abelson, 2019).

Project-Based Learning: Project-based learning enables students to apply CT skills in real-world scenarios, reinforcing their knowledge and allowing educators to assess their progress. Integration of CT into subjects like math and science demonstrates its relevance and applicability across disciplines (Kong & Abelson, 2019).

Collaborative Learning: Collaborative learning methods in virtual spaces enhance CT education. Tools like virtual breakout rooms and collaborative whiteboards support teamwork, enabling students to share strategies and solutions (Kong & Abelson, 2019).

Methodology

This research employed a systematic literature review guided by the PRISMA protocol. The objective was to identify effective methodologies for teaching computational thinking (CT) to non-programmers using artificial intelligence (AI) and virtual environments.

Data Sources: The review included exhaustive searches of the following academic databases: ScienceDirect, Scopus, Springer, and Google Scholar, due to their broad scope and quality in terms of indexing scientific literature.

Search Strategy: The following search equation specifically designed to capture publications relevant to the research topic was used: TITLE-ABS-KEY("computational thinking" OR "logical thinking") AND TITLE-ABS-KEY("non-programmers" OR "non-programmer") AND TITLE-ABS-KEY("artificial intelligence" OR "AI") AND TITLE-ABS-KEY("virtual environments" OR "e-learning" OR "online learning" OR "digital learning").

Inclusion Criteria

1. **Thematic relevance**: Studies focused on the teaching of computational thinking (CP) to non-programmers, with emphasis on the use of artificial intelligence (AI) or virtual environments.
2. **Empirical design**: Publications that present empirical data, including quantitative, qualitative, or mixed analyses.
3. **Time range**: Articles published between 2015 and 2024.
4. **Language**: Publications available in English or Spanish.
5. **Academic quality**: Peer-reviewed studies published in recognized scientific journals, conferences, or book chapters.
6. **Educational context**: Research conducted in formal or informal educational settings that includes strategies applicable to non-programmers.
7. **Full availability**: Documents with full access to the text for thorough evaluation.

Exclusion Criteria

1. **Lack of empirical data**: Theoretical or reflective studies that do not present empirical evidence.
2. **Duplicates**: Publications that appear repeated in different databases.
3. **Thematic irrelevance**: Documents not related to the teaching of CP, AI or virtual environments.
4. **Non-peer-reviewed publications**: Technical reports, theses, opinions, or popular articles without formal academic review.

5. **Lack of specificity**: Studies that address advanced programming skills rather than initial approaches for non-programmers.
6. **Methodological limitations**: Documents that do not clearly describe the methodology, results or findings.
7. **Unsupported language**: Articles published in languages other than English or Spanish.

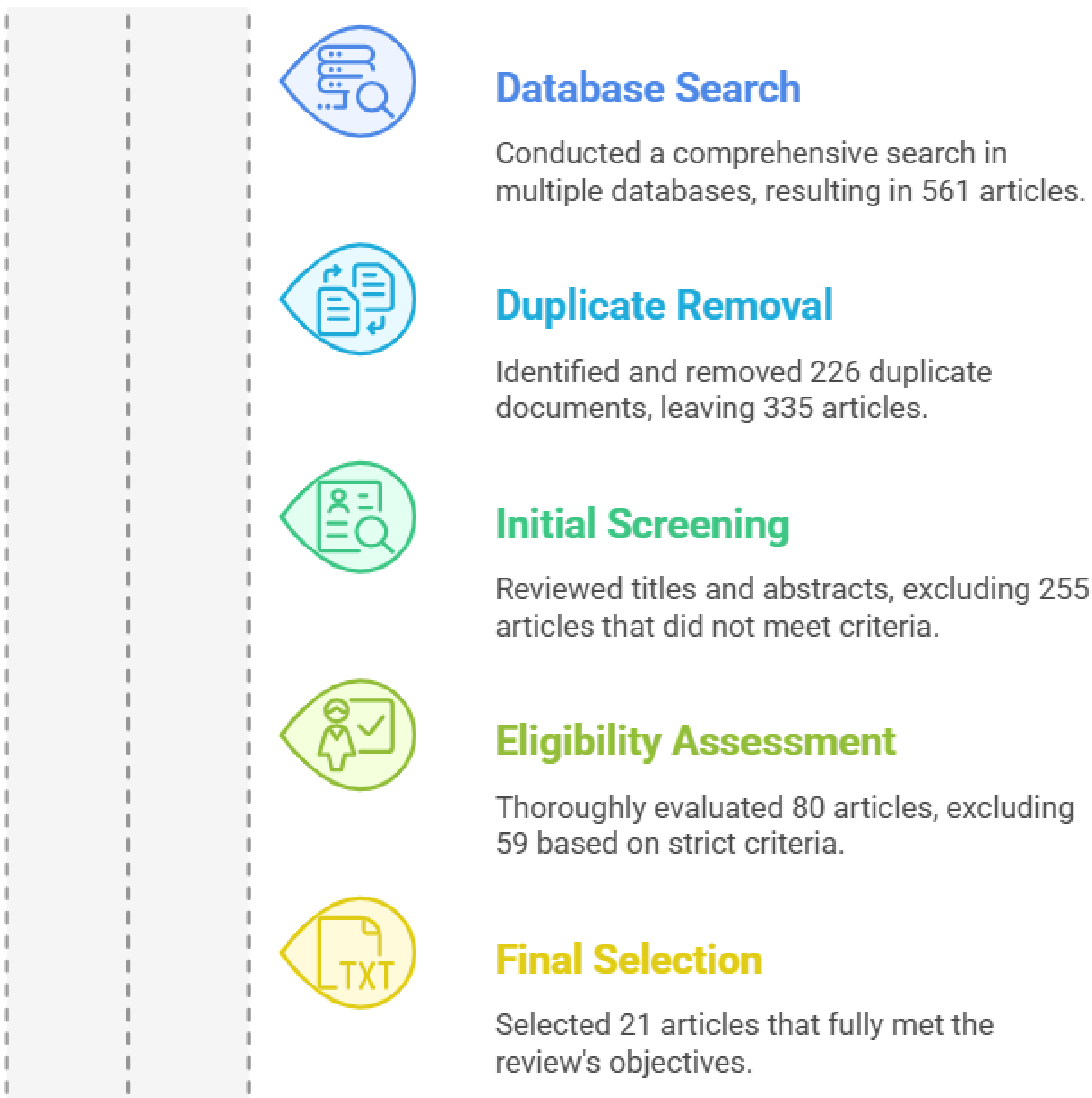
Results

Figure 1 presents the result of the systematic review protocol to identify, analyze, and synthesize the relevant literature on the teaching of computational thinking (CP) to non-programmers, with a particular focus on the use of artificial intelligence (AI) and virtual environments. This protocol, based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, was designed to ensure rigor, reproducibility and transparency at every stage of the process. The literature search was carried out in four recognized academic databases: ScienceDirect, Scopus, Springer and Google Scholar. These sources were selected because of their global coverage and their ability to index high-quality publications in the educational and technological fields. The initial search generated a total of 561 documents, which then went through several stages of filtering and selection.

First, 226 duplicate articles were removed, leaving 335 unique documents for review. Subsequently, an initial filtering of titles and abstracts was carried out, which allowed 255 articles that did not meet the established inclusion criteria to be excluded. The remaining 80 documents were evaluated in full text to determine their relevance and quality, applying rigorous criteria. As a result, we excluded an additional 59 studies because they did not meet specific objectives or lacked empirical data. Finally, 21 articles were selected to be included in the systematic review.

The selection process was guided by clearly defined inclusion and exclusion criteria. The selected studies had to focus on teaching the PC to non-programmers and integrate AI or virtual environments as part of the pedagogical methodologies. In addition, priority was given to peer-reviewed publications, available in English or Spanish, and published between 2015 and 2024. On the other hand, duplicate documents, theoretical studies without empirical data, and those that did not clearly detail their methodologies were excluded. Data extracted from the selected studies were analyzed qualitatively to identify patterns, trends, and gaps in the literature. Tools such as Excel were used to organize and visualize the data, as well as artificial intelligence tools such as Chat GPT to perform thematic analyses. This approach allowed for a detailed synthesis of the findings and facilitated the identification of key areas for future research.

Figure 1. Systematic Review Protocol



Temporary Distribution of Publications

Figure 2 shows an upward trend in the number of publications related to the topic from 2016 to 2024, reaching its peak in 2024, with 7 papers published that year. This increase reflects a growing interest in the use of AI and virtual environments for PC teaching, especially in innovative educational contexts.

Figure 2. Annual distribution of publications (2016-2024)

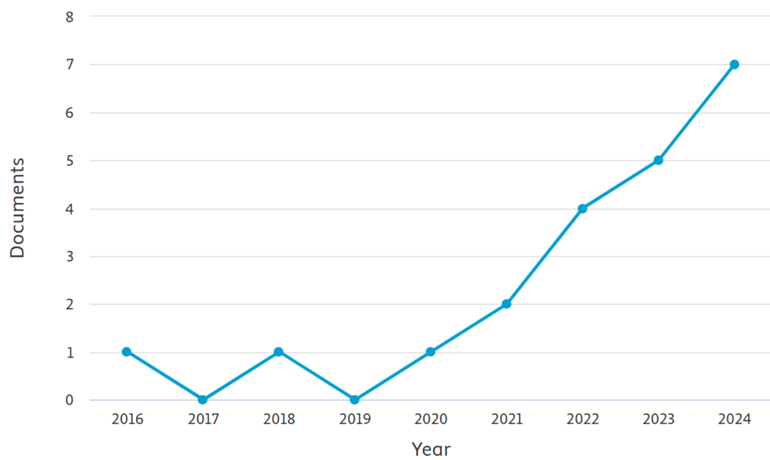


Figure 2 shows the number of articles published per year. There has been a steady increase since 2016, with 2024 standing out as the year with the highest academic production.

Distribution by Thematic Areas

The distribution of publications by thematic areas illustrated in Figure 3 shows a predominance of studies related to **Computer Science**, which represent 31.3% of the total articles reviewed. It is followed by **Social Sciences** with 22.9% and **Engineering** with 18.8%. These areas stand out for their focus on the integration of emerging technologies, such as artificial intelligence (AI) and virtual environments, in the educational field.

Other areas with significant contributions include:

- **Mathematics (6.3%)**: Studies investigating the relationship between mathematical skills and the development of computational thinking.

- **Psychology, Physics and Astronomy, and Materials Science (4.2% each):** These areas address topics such as cognitive competencies associated with CP and the use of immersive technologies in specific educational environments.
- **Medicine, Health Sciences, and Chemistry (2.1% each**): More limited approaches that apply CP in simulation design and data analysis.

Figure 3. Distribution by thematic areas

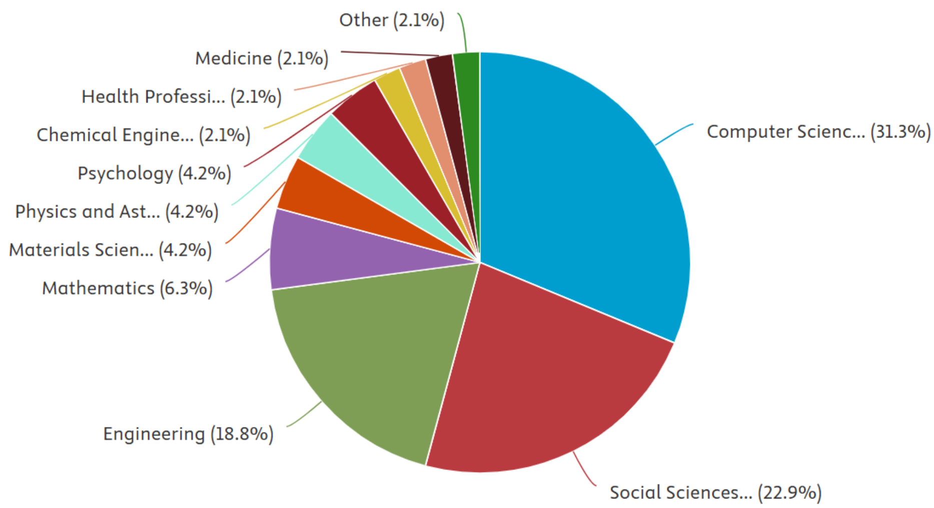


Figure 3 illustrates the research focus areas, highlighting that 31.3% of studies originate from Computer Science, followed by Social Sciences and Engineering. This concentration emphasizes the growing role of these disciplines in driving educational technology advancements.

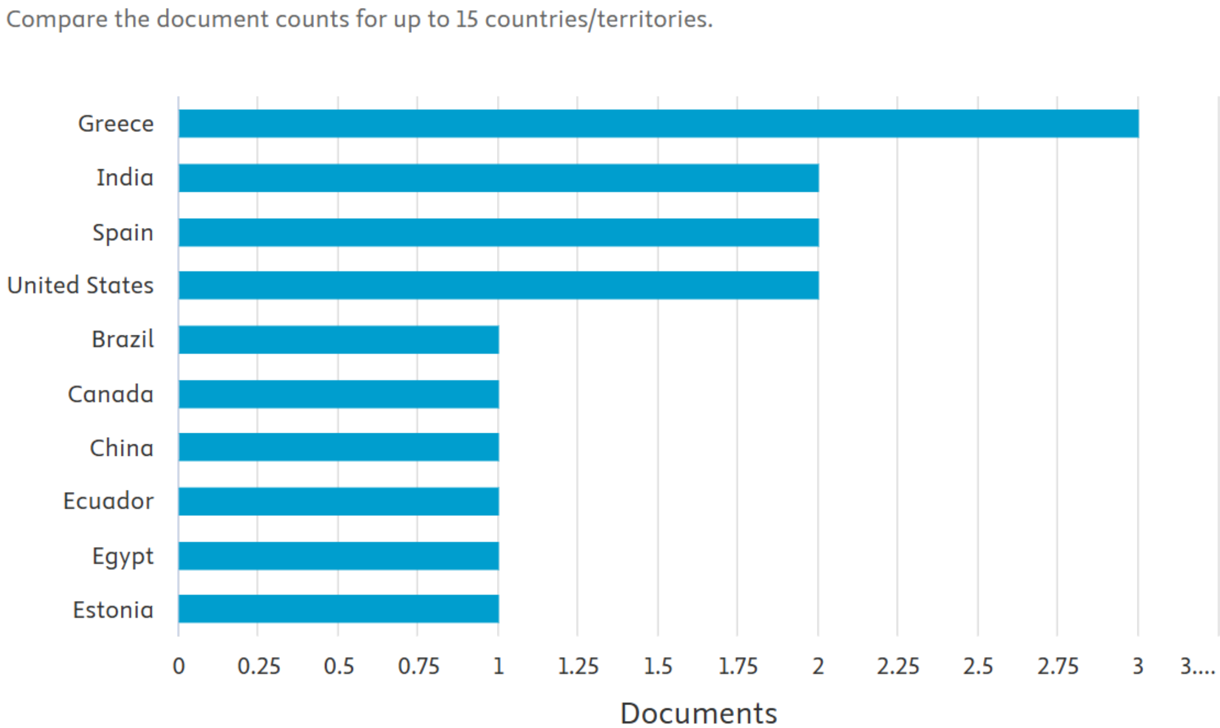
Geographical distribution

The geographical distribution of the publications reviewed in Figure 4 reveals that the largest number of documents come from **Greece**, with a total of 3 documents. This positions the country as a leader in research related to the use of educational technologies to teach computational thinking. It is followed by:

- **India**, **Spain** and **the United States**, each with 2 documents, reflecting their strong interest and contribution to the development of innovative educational methodologies.
- Other countries such as **Brazil**, **Canada**, **China**, **Ecuador**, **Egypt** and **Estonia** have a

moderate contribution, with 1 document each.

Figure 4. Geographical distribution of publications



The distribution shown in Figure 4 shows a notable contribution from countries in Europe and Asia, with Greece standing out as the one with the highest number of publications, followed by India, Spain and the United States. This reflects the growing global relevance of the issue, although it highlights the need for greater representation of developing countries such as those in Latin America.

Below are some uses of ICT to promote Digital Skills in applied research projects: Virtual Learning Environments (VLEs): VLEs are online platforms that can be used to deliver courses and training materials. They can be a valuable tool to promote Digital Skills, as they allow learners to access content at their own pace and from anywhere in the world. Massive Open Online Courses (MOOCs): MOOCs are free courses that are open to anyone. They can be a great way to introduce people to digi-tal skills, as they offer an accessible and low-cost way to learn. Online tutorials and resources: Online tutorials and resources can be used to learn about digital skills. They can be a valuable resource for people who want to learn more about specific topics or who want to brush up on their skills. Communities of practice: Communities of practice are online groups where people can share ideas and experiences about digital skills. They can be a valuable resource for people who want to learn from others and who want to stay up to date with the latest trends in digital technol-ogy. Some studies have found that digital skills can be used to improve the efficien-cy and effectiveness of applied research projects. For example, Aguilar & Romero-Rodríguez (2020) he found that data analysis tools can be used to identify trends and patterns in data. Gao, Chuang, Murphy, & Anderson (2020) He dis-covered that prototyping tools can be used to develop new products or services. Okoye, Adedeji, Oladejo, & Idowu (2023) found that Digital Skills can be used to communicate with stakeholders.

Discussion:

Aguilar & Romero-Rodríguez (2020), Gao, Chuang, Murphy & Anderson (2020), Okoye, Hussein, Arrona-Palacios, Quintero et al. (2023) found that digital skills can be used to improve the efficiency and effectiveness of applied research projects by helping to collect and analyze data, develop prototypes, and communicate with stakeholders. They found that digital skills can be used to use data analytics tools to identify trends and patterns in data, prototype new products or services using 3D printing or other digital manufacturing technologies, and use social media to communicate with stakeholders and gather feedback. García-Holgado & Román-Hernández (2022) found that digital skills can be used to improve the design and im-plementation of applied research projects. They found that digital skills can be used to use cloud computing platforms to store and share data, use project management software to track project progress, and use online collaboration tools to work with team members in different locations. López-Martín & González-Sánchez (2022) found that digital skills can be used to develop new products, services, and processes in the field of CSE. They found that digital skills can be used to design and develop new software applications, create new marketing campaigns, and optimize business processes. They can also be used to collaborate with other professionals in other countries. One of the uses was con-ducting online forums to discuss technical issues, such as using video conferencing tools to collaborate on projects and relying on social media to connect with other professionals in the field.

One of the challenges is that digital skills are constantly evolving, which means it's important to continually learn new skills and stay up to date on the latest trends. Another challenge is the cost of acquiring some specialized skills that require soft-ware licenses and specific training. However, there are opportunities to promote open innovation through collaboration with other actors, optimization of resources and expertise, and promotion of business innovation by generating new products, services, or processes, which helps companies stay at the forefront of technological development.

Through the systematic review, it was possible to identify a lack of research on the impact of digital skills on innovation in different sectors of the economy in Latin America, with the exception of Mexico. Although Aguilar & Romero-Rodríguez (2020) found that digital skills can be used to improve the efficiency and effectiveness of applied research projects in the field of CSE, there is no clarity on how digital skills impact innovation in other sectors, such as services, manufacturing, health, or education. On the role of Digital Skills in the development of new business models, few studies have been found, and the use of Digital Skills for innovation in applied research projects that contribute to job creation, new income, new markets or disruptive improvements in existing ones is not known.

There are challenges and opportunities in using digital skills to promote innovation in developing countries, as there is little research on the challenges and opportunities of using digital skills to promote innovation in applied research projects in developing countries. López-Martín & González-Sánchez (2022) found that digital skills can be used to collaborate with other CSE practitioners from other countries around the world. However, it is not defined how the use of digital skills could overcome the challenges of poverty, illiteracy and lack of infrastructure in developing countries, especially in Latin America and the Caribbean.

The growing importance of digital skills for data analysis is be-coming increasingly important in the field of CSE. This systematic review was able to identify that there are trends and patterns in data, which can help inform decision-making and innovation, such as the World Economic Forum study (2020) that found that data analytics skills are one of the top 10 skills that will be in demand in the next five years.

The increasing use of cloud computing and artificial intelligence are two major trends in the field of CSE. These technologies are used for business innovation that seeks to develop new products, services, and processes, and are also used to improve the efficiency and effectiveness of existing processes.

The growing importance of collaborative skills in promoting open innovation is becoming increasingly important in the field of CSE. This is because the applied research projects that are formulated in CSE are often complex and require the collaboration of people from different disciplines. Research from the National Academies of Sciences, Engineering, and Medicine (2019) found that collaboration skills are one of the most important skills for workers in the 21st century.

Online learning platforms and virtual labs/simulations are two common areas where digital skills are applied in distance learning programs for Computer Science and Engineering. Online learning platforms use online platforms and learning management systems to deliver course materials, assignments, and assessments. These platforms often include interactive features, discussion forums, and collaborative tools that allow students to develop digital skills while interacting with course con-tent (Nwaobi, 2014). On the other hand, virtual labs and simulations are used to provide hands-on experience. These tools allow students to practice programming, experiment with software and hardware systems, and simulate real-world scenarios. By using these digital tools, students can develop practical skills in Computer Science and Engineering (Nwaobi, 2014).

How do distance learning programs in Computer Science and Engineering pro-mote innovation through the application of digital skills? Distance education pro-grams in Computer Science and Engineering promote innovation through the application of digital skills in a variety of ways. For example, research projects in distance university programs often use various digital tools and technologies to facilitate innovation. These may include programming languages, data analysis software, simulation tools, virtual reality (VR) or augmented reality (AR) technologies, and cloud computing platforms. Digital skills also play a crucial role in the analysis and visualization of research data. Researchers use programming languages and statistical software to process and analyze large data sets, identify patterns, and gain meaningful insights. Data visualization tools are also employed to present research results in a visually appealing and understandable way. In addition, digital skills allow re-searchers to collaborate effectively in distance university programs. Online collabo-ration platforms, project management tools, and video conferencing software are some examples of tools that facilitate remote collaboration and communication between researchers (Fernández-Sánchez & Aguaded, 2016).

According to (Nwaobi, 2014), Digital Skills that are applied in research projects in distance university technology programs include: 1. Digital tools and technologies: Programming languages, data analysis software, simulation tools, virtual reality (VR) or augmented reality (AR) technologies, and cloud computing platforms (Nwaobi, 2014). 2. Data analysis and visualization: programming languages and statistical software to pro-cess and analyze large data sets, identify patterns, and obtain meaningful insights. Data visualization tools are also employed to present research results in a visually appealing and understandable way (Nwaobi, 2014). 3. Collaborative research: Online collaboration platforms, project management tools and communication technologies to facilitate effective collaboration between researchers (Nwaobi, 2014).

Farid Mutohhari et al. (2021) It discusses the importance of training programs, self-development, and motivation in improving digital technology skills and explores the integration of various approaches used in university education to develop the concept of digital skills management. From the above, the following questions or reflections arise: What are the specific digital skills that are most important for applied research projects in Computer Science and Engineering? How can digital skills be used to promote innovation in Computer Science and Engineering? What are the challenges and opportunities for the use of Digital Skills in applied research projects in Engineering and Computer Science? What are the implications of increasing the use of Digital Skills in Computer Science and Engineering for education and training?

This study provides valuable information on scientific production in Digital Skills and applied research projects. Through various techniques such as network analysis, citation analysis, thematic content analysis, and temporal trends, it was possible to characterize the research landscape in this field. A relevant finding is the identification of clusters of collaboration between authors and institutions, mainly from Spanish universities. This could be partly due to higher education policies in Spain that since the early 2010s have emphasized the integration of digital technologies and the development of digital skills (Prendes, Martínez & Gutiérrez, 2018). In fact, the increase in publications since 2016 could be related to the implementation of the Educa Digital program in Spain, which promoted educational innovation with the use of ICTs (Area, Alonso, Correa et al. (2014). Future studies could analyze in detail the Spanish policies and programs that led to this academic productivity (Santos, Fidalgo & Sein-Echaluce,,2021).

Another relevant finding is the thematic evolution towards issues of educational innovation, computational thinking and digital skills. This is in line with the grow-ing influence of digital technologies in education and the need to train professionals with strong digital skills. In fact, the COVID-19 pandemic accelerated the adoption of digital education and highlighted the importance of technological and innovation skills. This could be an area for future bibliometric research.

Among the limitations of this study is the focus on specific databases, so the in-corporation of other sources could complete the picture. In addition, given the inter-disciplinary nature of this field of research, analysis of connections to computer science databases could provide additional information. Future studies could also employ more advanced bibliometric techniques, such as the analysis of networks of joint words. Nonetheless, this study helped characterize the research landscape, major themes, and collaborations in this emerging field. The analysis of the literature on Digital Skills and technological projects provides a comprehensive view of the state of this area of research. Collaboration between authors and institutions, increased productivity, and identified thematic changes provide a starting point for more detailed studies on the factors influencing these trends. Continuous examination of research dynamics in this field through biblio-metric methods can inform the design of educational policies, the formulation of research projects, and the strengthening of collaborative networks.

The results reviewed show that visual programming tools such as Scratch and Alice are effective in promoting the development of computational thinking, especially in early educational contexts. Arranz and Pérez (2017) highlighted that these tools facilitate the understanding of key concepts such as sequences, loops, and conditionals, as well as stimulating creative and metacognitive skills. Similarly, Allsop (2019) highlighted that the creation of games through visual platforms enhances logical thinking and problem-solving, positioning programming as a transformative tool for learning. These findings reinforce the need to integrate visual tools into core educational curricula, especially in non-technical contexts. However, the need to investigate their effectiveness at more advanced educational levels and in populations with less access to these technologies is identified. In addition, the incorporation of predictive models, such as those proposed by Hooshyar and Druzdzel (2024), facilitates the anticipation of student performance, optimizing adaptive teaching processes.

Implementing smart educational environments represents both significant opportunities and challenges. Alfoudari et al. (2021) pointed out that the adoption of educational platforms, such as Microsoft Teams, is conditioned by the perception of usability and technological training of users. During the pandemic, Pal and Vanijja (2020) showed that student participation depends to a large extent on the ease of use of these tools, highlighting the importance of technological training for teachers and students. The successful integration of these platforms requires sustained investments in training and cultural adaptation in diverse educational contexts. In addition, the importance of exploring how these technologies can be scaled up in countries with limited technological infrastructures is highlighted. The implementation of AI-based gamified chatbots, such as the one developed by Xu et al. (2024), has demonstrated significant improvements in academic performance and in the development of critical thinking in virtual environments.

Teacher professional development emerges as a key element for the effective teaching of computational thinking. According to Kong, Lai, and Li (2023), professional development programs must address both technical skills and pedagogical strategies to ensure effective implementation. Likewise, Ayanwale et al. (2022) emphasize that teachers' confidence in their ability to teach emerging technologies is a crucial factor for their adoption in the classroom. Teacher education requires not only the acquisition of technical skills, but also a cultural and social approach that mitigates resistance to change. Accessible training programs designed for resource-limited settings are essential to maximizing impact.

Computational thinking has the potential to transcend its technical application and be integrated into broader disciplines, such as the social sciences, humanities, and art. Kong et al. (2023) suggest that teaching computational concepts in non-technical subjects can make these skills more inclusive and applicable in diverse contexts. For example, music and design can benefit from AI-powered platforms that allow students to explore logic and problem-solving concepts in a contextualized way. This interdisciplinary approach is recognized as an essential step towards the democratization of computational thinking.

Conclusions

This study identified effective strategies for teaching computational thinking (CT) to non-programmers, particularly through AI and virtual environments. Future research should focus on expanding access to these tools in underserved regions and exploring long-term outcomes of these methodologies. This allows us to conclude:

- Strategies based on visual programming tools, gamified activities, and unplugged methods have proven to be effective in developing the PC in students with no programming experience. These methodologies not only promote the acquisition of technical skills, but also logical thinking, creativity, and problem-solving.

- AI and virtual environments, such as smart classrooms and simulators, make it possible to personalize learning and improve student engagement. Their ability to offer real-time feedback and adapt to individual needs reinforces their usefulness as key pedagogical tools. However, its implementation faces challenges related to costs, accessibility, and technological training.

- The use of emerging technologies in education, including AI and virtual environments, has shown a positive impact on the teaching of computational thinking. However, as Voskoglou and Salem (2020) state, there is a need to address limitations in access to these tools, especially in developing countries. It is recommended to implement inclusive strategies that allow the democratization of learning and an ethical approach in the use of AI in education.

- CP has the potential to be integrated into non-technical disciplines, such as the social sciences, humanities, and arts. These applications expand the reach of the PC, promoting the democratization of access to critical digital skills across a wide range of populations and educational contexts.

- Factors such as fluid intelligence and visuospatial ability significantly influence the development of CP. These findings underscore the importance of designing educational activities that consider individual differences, favoring more personalized and inclusive learning.
- The integration of AI in education poses ethical challenges related to equity, privacy, and accessibility. It is essential to establish regulatory frameworks that guide its responsible implementation. In addition, knowledge gaps persist, such as the lack of longitudinal studies and the need to investigate their impact on marginalized populations, which must be addressed to ensure sustainable and equitable learning.

Availability of data and materials

This is a review paper and all data has been presented throughout the paper. Declarations Competing interests the authors have no competing interest to declare

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Author contributions

DLF was in charge of the research design, data collection and analysis, and writing. RDCE was in charge of conceptualization, JCCE was in charge of data analysis, writing and editing. The author(s) read and approved the final manuscript.

Competing interests section

There are no competing interests to declare.

We declare no competing interests.

This work was conducted in the absence of any competing interests.

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