STATE OF THE ART OF TEACHING COMPUTATIONAL THINKING IN PRESCHOOL AND ELEMENTARY EDUCATION

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ABSTRACT

The development of computational thinking is one of the challenges of the current educational system, since in the knowledge society in which we find ourselves, the ability to solve and decompose problems, pattern recognition, abstraction and algorithmic thinking are factors that facilitate the development of skills and competencies required by the citizens of the future in the digital era we face. Taking into account the above, the purpose of this article is to conduct a documentary review on the state of the art of teaching computational thinking in preschool and elementary school, therefore, it is presented as a theoretical review, where the method corresponding to a descriptive and interpretative study is used through a hermeneutic documentary analysis of the literature consulted. To achieve this purpose, the concept of *"computational thinking"* is initially approached in relation to other concepts such as 21st century literacy, preschool and primary education, educational trends and teacher training. Subsequently, a database generated from the review of the publications of the last five years in academic search engines that emerged from the empirical research is analyzed. Finally, we proceed to a discussion of the results found and the research needs in this regard.

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One of the major conclusions that can be drawn is the marked tendency to associate the development of computational thinking with programming and technologies such as educational software, video games and robots. Efforts to develop *"unplugged" or "disconnected"* strategies for areas other than mathematics and technologies are still in an incipient state.

Keywords: Computational thinking, 21st century literacy, preschool education, elementary education, teacher updating.

INTRODUCTION

In its effort because more and more countries see ICTs as a tool that generates opportunities for sustainable development, UNESCO (2019)1 in its different annual conferences, continues to insist nations on the importance of establishing plans that allow students to approach, know and master ICTs.

The competencies generated based on the use and appropriation of Information and Communication Technologies (ICT) and computational thinking are cognitive conditions that complement, enrich and transform teaching and learning processes to face the challenges of globalized education. According to the United Nations Educational, Scientific and Cultural Organization UNESCO (2019) 1, ICTs promote and influence worldwide the construction of an inclusive knowledge society, human rights, empowerment and gender equality, gradually closing the technological gap through the achievement of goals outlined by the Sustainable Development Goals (SDGs), particularly embodied in Goal 4: Quality Education.

In Colombia, the Colombian Ministry of Information and Communication Technologies (MinTIC, 2018) is committed to closing the digital divide, and preparation in terms of digital transformation as a gateway to the Fourth Industrial Revolution (4RI). To achieve this, it aims to include ICT for digital development in the formation of empowered citizens of the digital environment and sectoral digital transformation.

The General Education Law of Colombia, in Article 5, numeral 13 explains that *"The promotion in the individual and in society of the ability to create, research, adopt the technology required in the development processes of the country and allows the learner to enter the productive sector"* (Law 115, 1994). In Colombia's ten-year education plan 2016-2026, the government is committed to mediate and promote the economic sphere and to carry out a social transformation through education.

For Delors (1996) it is necessary to take a look at the methodologies, resources and tools immersed in educational practices to elucidate how in a world increasingly immersed in ICTs, these favor the integral formation of citizens so that they can, according to Torres and Rositas (2011), solve problems of personal, work and social life taking into account the constant and accelerated transformation of today's world. In this sense, the incorporation and integration of ICT and computational thinking to the teaching and learning process, consolidates the appropriation of knowledge, skills and the development of students' abilities, for their incorporation to the pedagogical praxis and daily life, which has an impact on the impact and interaction of knowledge with other disciplines.

The new knowledge society and the digital era in which we find ourselves demand from educational systems curricular approaches in line with the transformations that the current reality demands in order to contribute to the development of skills required by the citizens of the future. In recent years, according to Caballero (2020), there has been a growing interest in different countries to incorporate into the curricula the new requirements of 21st century literacy, which include learning coding, programming and computational thinking from an early school age.

The development and implementation that ICTs have reached in recent years, according to Eskol (2017), demands from the educational system a constant updating of practices and contents that are in line with the society that emerges from these changes, turning educational practice into an activity to socialize and collaborate with others. Throughout the world, the increased use of technologies has marked the social dynamics, in such a way that they have become a tool for communication, work, education and leisure, and has disrupted schools. And, in fact, a great variety of research and significant experiences around the appropriation of ICT inside and outside the classroom, has shown the increase in the number of students with better school performance (Huerta and Pantoja, 2016).

Given the above, it is pertinent to trace the experiences developed with respect to pedagogical practices in which the development of computational thinking is integrated. The objective of this article is to conduct a documentary review on the state of the art of teaching computational thinking at the preschool and elementary school levels, presenting a theoretical review, where the descriptive and interpretative study method is used through a hermeneutic documentary analysis of the literature consulted.

In the first part of the article, a theoretical review and discussions about education, competency-based curriculum and 21st century literacy, computational thinking and preschool and elementary education, educational trends and teacher training are presented. In the second part, the research articles found are presented, followed by an analysis of a data bank generated from the review of the publications of the last five years in academic search engines that emerged from the empirical research.

As one of the major conclusions that can be drawn from all this information tracking and analysis is the existence of a marked tendency to associate the development of computational thinking with programming and technologies such as educational software, video games and robots. Efforts to develop *"unplugged"* or *"disconnected"* strategies for areas other than mathematics and technologies are still in their infancy.

CONCEPTUAL FRAMEWORK

COMPUTATIONAL THINKING AND LITERACY IN THE 21ST CENTURY

There seems to be no consensus in the scientific community on the concept of Computational Thinking. Gonzalez-Gonzalez (2019) highlights that, although the concept of *"computational thinking"* is generating growing interest, it really emerged in the 1960s with S. Papert in 1980 and his constructivist approach to the LOGO programming language, which helped students in the creation of their own problem-solving processes. The author adds that computational thinking is the ability to use concepts from computer science to use them in problem solving.

Quoting Sarmiento (2019), of computational thinking it was found that there are several professionals in the field of education, computer science and sciences who have developed concepts about what it is and how it could be developed. In 2006 Jeannette Wing began to raise the importance of fostering computational thinking in students as a fundamental skill for everyone, not only for computer scientists, the author indicates that *"computational thinking involves solving problems, designing systems and understanding human behavior, making use of the fundamental concepts of computer science"* (2006, p. 33).

Computational thinking, according to Gordillo et al. (2017) refers to the process of problem solving using ICT as mediators, and students who develop Computational Thinking can better understand the relationship between school subjects and life inside and outside the classroom. Angel et al. (2020) add that applying Computational Thinking can lead to effective complex problem solving and that the main skills fostered by it are the following:

1. Problem decomposition: for the recognition of the simplest subproblems to be solved, whose solution as a whole would provide a solution to the original problem.
2. Pattern recognition: for the identification of similarities between different problems. This will make it easier to solve them.
3. Abstraction: to treat a problem with a high degree of detail.
4. Algorithmic thinking: for the generation of algorithms or steps to solve the problem, trying to be as general as possible so that similar problems can be solved with similar algorithms.

For Motoa (2019) computational thinking favors critical thinking since it favors the germination of ideas product of abstraction and the execution of projects contextualized to the students' reality. Vilanova (2018) affirms that computational thinking complements mathematical thinking with engineering since computation has its foundations in mathematics and engineering provides the base philosophy on the constructs that interact with real life. For the author, from the educational point of view, software development allows the activation of a wide variety of learning styles and the development of computational thinking and involves students to consider the different variables that can have the solution of a problem: its nature, subproblems, algorithms and solution strategies.

Caballero-Gonzalez and Garcia-Valcarcel (2020) state that society requires the adoption of a new literacy that favors decision making in the face of daily challenges through the organization and efficient use of information and communication technologies. Motoa Sabala (2019) states that there is a need to move from being simple consumers of technology to start producing them and that the development of computational thinking favors this transition; the author mentions that Colombia has been taking steps in this direction by incorporating within the curricula actions for its genesis and implementation.

EDUCATION AND CURRICULUM BY COMPETENCIES

Education is characterized as a social process, where knowledge, skills and competencies are acquired, and its current perspective is to focus academic training on pedagogical innovation and the increasing pace of scientific and technological advances, and the application of various learning strategies that have led to the creation of theories, theses and educational proposals in search of answers that generate the processual dissipation of difficulties in the development of teaching and learning processes, in order to acquire and promote an inclusive, relevant, competitive and quality education.

It is necessary to analyze competency-based training, involving strategies, methodologies and the application of technological resources to the curriculum, as well as the active participation of teachers and students in the construction of new knowledge; at the same time, it is important that the educational community is interested and motivated towards change to enable the development of better and innovative learning environments that contribute to the development of competencies. However, Hinostroza (2017) states that, at present, the second digital divide shows the difference in the development of competencies in young people and adults to take advantage of the academic and labor benefits of the efficient management of technology.

The above leads to think of an innovative and globalized education that, according to Avendano (2016), fulfills its responsibility of transforming society and expanding capabilities and human development. To be competent, according to Sierra (2016) is to have sufficient skills to face global challenges. It is imperative that governments formulate policies that lead educational institutions to provide the necessary elements to design and foster experiences in the teaching and learning processes, as well as make the relevant curricular modifications and provide actions that promote the quality of education from a collaborative perspective, and thus strengthen the foundations of a comprehensive society. It is also necessary to dynamize processes and carry out exhaustive analyses in order to determine possible causes, provide solutions, and identify approaches, trends, strategies and changes that allow for improvements in training methodologies, design and implementation of strategies that generate progress and innovation in education.

Complementing the above, Jurado (2021) states that it is essential to rethink the teaching and learning processes, especially considering the changes generated by the pandemic, which will greatly favor curricular integration and make it possible to propose curricula by competencies where the learning processes allow, based on the contexts, to be flexible, use simple strategies, clear languages, dialogue, expression of emotions, teamwork and evaluation designed for the student not to punish but to learn from the situations and difficulties. This will allow the teacher and the student to evaluate what has been learned through a systematic process called formative evaluation.

COMPUTATIONAL THINKING IN PRESCHOOL AND ELEMENTARY SCHOOL EDUCATION

Sullivan and Bers (2016) state that computational thinking is considered a social necessity of this century, because it greatly favors competencies and training in different basic skills and abilities that allow students to solve problems and create possible solutions in a creative way, since it involves imagination, creativity, mathematics, teamwork in a collaborative manner, developing the ability to solve problems.

According to Lastra, (2019), computational thinking has generated a growing interest at different educational levels, which has led to the emergence of numerous government and private proposals for the development of coding skills in programming languages, especially in the early school stages. According to Sanchez, (2021), despite the lack of publications and studies in the field of early childhood education, there is a tendency to include robotics and programming in early education classrooms, and that it is also evident the approach of curricular proposals that seek to promote the integration of computational thinking (with technologies or not) in children.

According to Gonzalez-Gonzalez (2019), early education is the stage in which the foundations should be planted for a comprehensive and quality education using innovative tools and technology. The author adds that coding or programming is the new literacy and for this reason it is necessary to integrate computer literacy at an early age, ideally through technologies that support game-based learning, since it makes children creators, designers, problem solvers, and artists, i.e., they become digital producers.

According to Delgado and Prado (2018) computational thinking is something that should be taught from the early years, thus generating in children the need to solve problems, following different steps that allow them to see several solutions, as well as accepting the point of view of others and thus encouraging the formation of values; such as respect, tolerance and acceptance, which are fundamental to form citizens of the future. For Segura et al. (2017), the sources used in pedagogical practices for computational development should be contextualized to the daily life of children, thus, a real-life problem solving approach would seem the most appropriate to be used taking into account the progression from the simplest to the most complex.

Citing Zapata (2015), learning programming and the skills necessary for coding should be detected and developed from the early stages of people's lives, just as it happens with other key skills for children to advance in their formative processes.

COMPUTATIONAL THINKING AT SCHOOL AND TEACHER TRAINING

Pedagogical practices have been changing over time. The historical, psychological and sociological situations that lead to the acquisition of knowledge are inherent to the changes that permeate society. The work in the classroom and therefore the curriculum are included in this transformation, where the teacher is the main precursor of the implementation of innovative practices based on competency-based learning. As stated by Nino et al. (2017), teachers who have managed to transform their classroom practices have done so based on pedagogical models that favor the process of applying competencies.

According to Tellez (2019), more than 70 years have already passed since the appearance of the first computers that have evolved into Information and Communication Technologies (ICT) that allow people to communicate and manage information, and these have permeated almost all human activities and have changed the forms of communication, consumption, learning, teaching, coexistence, work, among others and given all the above, the roles of people in an increasingly technified society are being rethought.

Martinez et al. (2017) describe that computational thinking is one of the competencies that allow any person, the management of any situation; and that, although participation in activities related to robotics or programming do not guarantee the acquisition of them, teachers should plan and include them in the curricula and therefore should prepare for them. To begin in this regard, according to the authors, the first step is to achieve a change of mentality in teachers so that they begin to incorporate related practices in their classrooms. The authors point out that normally teachers have not been trained to teach computational thinking and do not even know what it is.

That said, the learning processes used to develop the approach of a competency-based curriculum as in the case of the development of computational thinking should enable the implementation of methodological strategies that allow the teacher to be a guide and the student to build their learning, always from the relationship with the other and the experience, where the evaluation serves to redirect, observe and rethink, individually and collectively and not as a punishment or goal to be reached as completion of a process, but rather as a starting point in the acquisition of meaningful learning.

UNESCO (2019) states that it is useless if institutions are only provided with equipment, it is then necessary to offer training to teachers and also establish strategies that allow the proper incorporation of ICT into education systems to contribute to the development of digital, citizenship, labor and cultural competencies. In other words, it is a great step forward for governments to generate educational public policies to incorporate the use of technological resources in educational practice in order to reduce learning gaps and work on equity.

Citing Vinals, and Cuenca (2016), the teacher must be a guide of the methodological process, and in this current globalized and changing society, it is he, the one called to develop innovative trends that are directed to the construction of coherent and creative curricula that motivate students to make critical use of technology not only in the classroom but also at home, in their social life and in their leisure environments.

The education of the future envisions making room for new ideas. In particular to the triad, between the development of cognitive processes, computational theories and technological development (Pulido, 2018), to solve complex multidisciplinary problems, specific to the context, experience and with acquired concepts, where we must not cling to blindly believe in pedagogical practices of the last century. Therefore, *"It is necessary to allow the student to become aware of the processes used in the production of knowledge, facilitating metacognitive reflection on cognitive processes [...]"* (Pulido, 2018, p.83), aiming at a change of intrinsic thinking, to teach to learn, to contribute to an awareness to acquire knowledge with meaning, enriching the models of education mediated by ICT, supporting new trends.

COMPUTATIONAL THINKING AND ICT

In ICT mediation, Veytia and Sanchez (2017) point out that there is a recognition by students of the importance of ICT in the teaching and learning process. In addition to the above, Barrera (2017), Cano (2016) and Hernandez (2015) state that the use of ICTs provides attractive and practical environments, but that it is a challenge to guide their use from the pedagogical point of view.

However, the use of technological tools favors the development of ICT competencies, which are defined as: *"The set of knowledge, skills, attitudes, understanding and cognitive, socio-affective and psychomotor dispositions appropriately related to each other to facilitate the flexible, effective and meaningful performance of an activity in relatively new and challenging contexts"* (MEN, 2013, p. 23).

According to Moreira (2019), ICTs make meaningful learning, contributing to the formation of the human being, in addition to impacting cognitive processes in the areas of knowledge: fosters the creation of novel ideas, develops the ability to interpret and acquire knowledge gradually, applying innovative techniques, which model and allow a dynamic analysis of the characteristics of many concepts, highlighting the potential and mediation of active methodologies with ICT that currently revolutionize student-centered learning, in labor competencies and in the application of a relevant assessment (Silva and Maturana 2017).

Similarly, the Organization of American States, OAS has stated that the incorporation of technologies in the education sector greatly favors countries to achieve the sustainable development goals proposed to be achieved by 2030 and that in turn, educational quality is guaranteed to all human beings without distinction. Thus, at some point, the international organizations that advocate so much for the incorporation of ICTs in the educational field, may have wondered what indigenous peoples want or desire and how the incorporation of ICTs in their communities can affect their customs?

Other organizations that have contributed to the importance of ICTs for the education sector are: the Inter-American Development Bank, IDB in 2010, proposed several aspects that should be taken into account for the successful insertion of ICTs in education; in 2011 it stated that it is essential that educational institutions have a good infrastructure, well developed projects and trained teachers to ensure the proper use of emerging technologies in schools.

COMPUTATIONAL THINKING AND UNPLUGGED DIDACTIC STRATEGIES

Lastra, (2019) add that the activities that allow the development of computational thinking without making use of technologies as a primary instrument development is what is called *"unplugged activities"*. However, it is commonly associated the development of computational thinking with the use of technologies such as software, video games and robots However Gonzalez-Gonzalez (2019) exposes that there are a large number of activities available to be used without screens or computers on the internet that keep databases of activities to work unplugged computational thinking with open licenses.

JUSTIFICATION, MATERIALS AND METHODS

A research of this nature, in which the state of the art of this specific topic is presented, is relevant because it presents a database of what has been researched to date on the development of computational thinking in preschool and elementary school, how the educational projects have been developed, what the conclusions and recommendations of the different authors have been, and how the information obtained from the research has been analyzed; All this knowledge should be acknowledged since it makes it possible to contrast practices and identify significant experiences that could lead to the planning and development of projects with more conclusive results in terms of the development of computational thinking in preschool and elementary schools. For researchers working in preschool and elementary education, this compendium is relevant because it presents an overview of what has already been researched, and thus, an overview of the gaps in knowledge that exist.

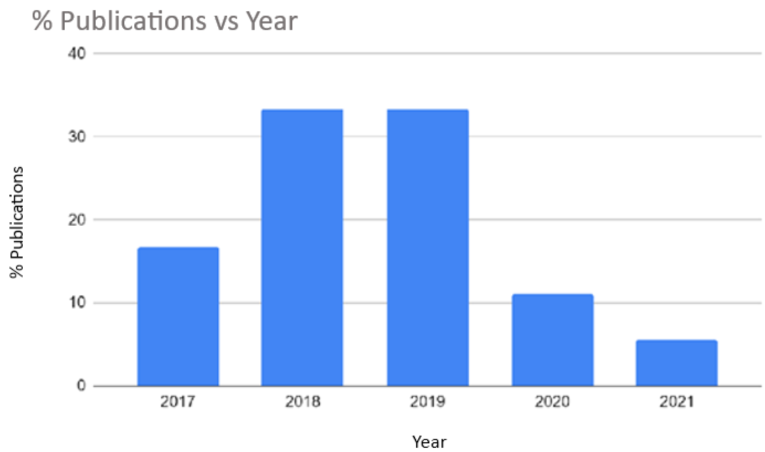
The present study is constituted as a descriptive research and bibliographic review in which articles resulting from scientific research and theses published between 2017 and February 2022 were traced in the Google academic search engine. This time criterion was used with the objective of reviewing the most recently published articles. Articles and theses were selected if their main topic was the development of computational thinking in preschool and elementary school students and teacher training.

A general review was made of these articles in order to recognize their general objectives, the methodology used by the authors for their development, the tools used, the population investigated, the results obtained, and the discussions raised. After having done this, an analysis of the characteristics of the articles and theses was made and a database was constructed which became the state of the art presented in this publication; finally, after the review process, conclusions and recommendations were generated regarding the needs in the field.

Between the dates indicated, a total of 18 published articles were found, of which two were doctoral theses, one of them for a doctoral degree in knowledge society formation and the other for a doctoral degree in systems engineering; one work for a bachelor's degree in computer science and another for a master's degree in educational informatics for teaching. The rest were research articles.

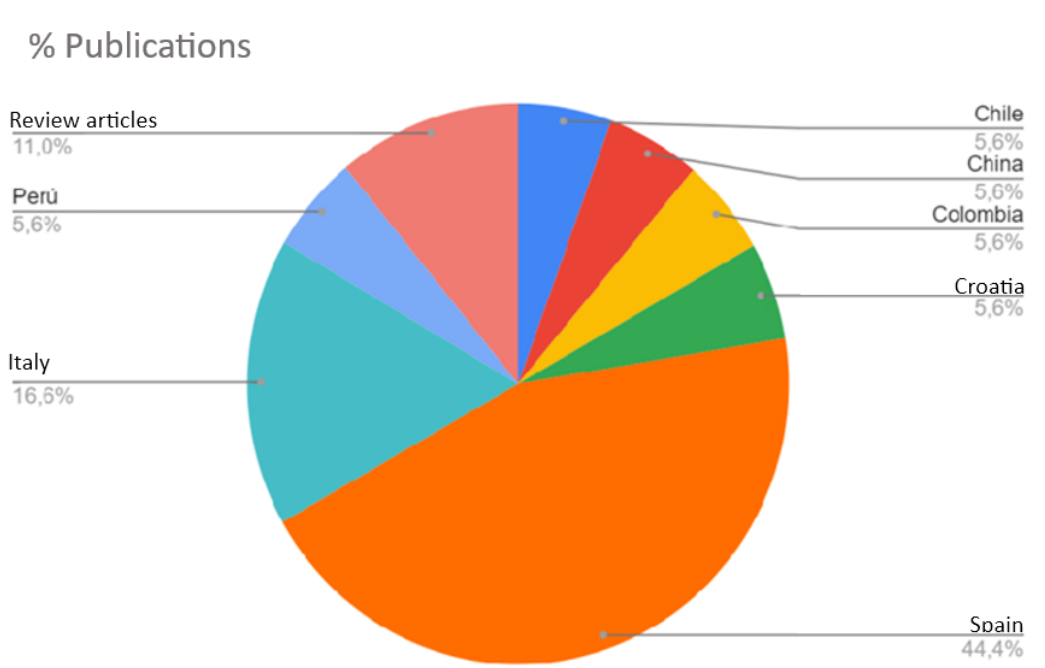
The highest number of publications was tracked for the years 2018 and 2019, see Figure 1. Of the total, in 2017 there were approximately 16.7% of publications, in 2018 and 2019 33.33%, in 2020 11.1%, in 2021 5.6% and no publications were found until February 21, 2022. In Europe there is a marked trend in research on the development of computational thinking in school with 66.6% of publications in that region, 16.8% in Latin America and 5.6% in Asia. Figure 2 shows that the country with the most publications is Spain, followed by Italy. Of the total, we found 11% of articles that summarized initiatives related to the development of computational thinking and another article that analyzed the relationship between concepts such as robotics, programming and computational thinking, which we call *"review articles"*.

Figure 1. Percentage of publications from 2017 to February 2022.



Source: Own elaboration after analysis of the information collected.

Figure 2: Percentage of publications by country, source: own, after analysis of the information collected.



Source: Own elaboration after analysis of the information collected.

RESULTS

Segura et al. (2017), conducted a discussion around the ideas of how to prepare future pre-school and elementary school teachers in the didactics of computational thinking. In their dissertation they collect ideas from scientific literature on how to develop the computational thinking of future teachers and how to train them to design, develop ideas and evaluate didactic activities on computational thinking in various areas of the early childhood and primary education curriculum.

Their research concludes that, despite its complexity, the most appropriate approach is the one that poses the solution of real-life problems. This is a novel initiative, given that a compendium of this type allows the experiences of other teachers to be collected, which can shed light on the best methodologies and strategies for implementing strategies that favor the development of computational thinking in the classroom for teachers who have no knowledge of the subject.

Arranz and Perez (2017) conducted an assessment of the computational thinking of elementary school students who worked with the Scratch software for which they developed a descriptive study with 28 students to whom a questionnaire was applied to evaluate how the use of this software affects the development of the different dimensions of computational thinking (computational concepts, practices and perspectives). It was found that the use of Scratch favorably affects the development of cognitive skills such as problem solving, reasoning skills, logical thinking and creativity.

Angel Alsina (2017) conducted a research on an experience with programmable educational robots to work on patterns in children aged 3-4 years with the aim of presenting some didactic guidelines to develop algebraic reasoning in early childhood education through computational thinking, using robotics as a resource. Among the conclusions reached by the researcher is that in the framework of STEAM education, reasoning processes should be encouraged through good questions and pose relevant phenomena based on problem solving and that representation should be raised as a means to understand, structure, capture and transfer concepts.

Roman et al. (2017) developed an instrument for measuring computational thinking and giving evidence of its nature through associations with related key psychological constructs. To achieve this, they initially applied a computational thinking test to a sample of 1251 students between fifth and tenth grades, so in their work they report descriptive statistics;

and finally they studied the criterion validity of computational thinking with respect to other standardized psychological tests: the Primary Mental Abilities Battery (PMA) and the RP30 problem-solving test. The results show that there is a correlation between computational thinking with reasoning ability and problem-solving ability.

Corradini and Nardelli (2017) investigated the conceptions of 972 Italian primary school teachers about what computational thinking is, this was developed in the framework of the project “Programma il futuro”. Teachers were asked to give a definition of what computational thinking is and to answer three additional related closed questions. The analysis showed that almost half of the teachers included in their definitions fundamental elements of computational thinking and very few were able to give a complete answer. Most teachers were aware that computational thinking is not strictly characterized by coding or the use of technologies.

Delgado and Prado, (2018) conducted a research where they analyzed the contributions of sensory stimulation through play to strengthen computational thinking in transitional schoolchildren. To achieve this, they started with diagnostic tests to detect the initial needs of the students, then they applied disconnected activities where the manipulation of objects and playfulness were the main axes for the generation of a learning environment; the authors concluded that from the intervention sensory stimulation is evidenced that allowed working and developing computational thinking, and that the activities contributed an increase in self-esteem, verbal expressiveness and that taking into account the whole experience, the favoring and development of computational thinking was achieved.

Garcia and Caballero (2018) developed an investigation to test the impact of the development of educational robotics activities on the acquisition of computational thinking skills. The research design was quasi-experimental, with pretest and posttest measures, using experimental and control group of a population of 131 students in the second year of early childhood education, i.e., students between 3 and 6 years old. The challenges were designed using the TangibleK program. Within the analysis it is found that the results obtained are positive regarding the computational thinking skills achieved and that there are significant and superior differences to those presented in the control group, thus it can be concluded that robotics activities contribute to obtaining greater advances in computational intelligence.

Chiazzese et al (2018), present the results of a project on computational thinking developed in 81 primary school children in Italy in which they asked students to design and develop computer games through the Microsoft Kodu gaming platform. In order to promote computational thinking skills, the researchers opted for a narrative approach throughout the project. Among the preliminary results of the experience, it was found that the narrative approach and the physical reproduction of manipulative programming objects are an opportunity for the development of this type of thinking. Additionally, they found that the program positively stimulated the students' perception of computer programming.

Boticki, I., Pivalica, D. and Seow (2018) presented the results of a research conducted in an elementary school on first grade students with whom a tool for the development of computational thinking was employed that allowed designing and delivering tasks with content in the areas of mathematics, science and reading. The tasks were aligned with the curriculum. The results reveal that the tasks related to object properties, problems and loops were the most cognitively demanding for the students and that previous skills in mathematics and reading have a positive impact on the students' performance in handling the challenges provided by the tool used.

Chiazzese, et al., (2019) conducted a study where they sought to evaluate the effect of a robotics lab on the acquisition of skills related to computational thinking in elementary school. Their study aimed to compare the magnitude of the effect of the lab between third and fourth grade students. To achieve this, they conducted a quasi-experimental post-test design applied to a group of 51 students who participated in the lab versus a group of 32 students who did not. The results obtained show that programming and robotic artifacts can have a positive impact on the learning of computational thinking skills and a greater positive effect was found in the interventions of younger children.

Gonzalez-Gonzalez (2019), presents a methodological proposal using the principles of the Positive Technological Development (PTD) framework, the maker movement, constructivism, inclusive education and learning through early childhood education games. The researcher used tangible manipulative robots with no need for connection (unplugged) and plastic and recyclable materials. The sequence used was: preliminary games, introduction of powerful ideas through a challenge, individual or group work, presentation and exchange of the final project, and exploration and free play. The proposal was validated in several contexts, thus demonstrating its effectiveness.

In another publication, the same author (2019), presents the review of the state of the art of teaching computational thinking and programming in the early childhood stage, in which she identified definitions of the teaching-learning of computational thinking and programming, identified the main initiatives for teaching PC and programming in early childhood education stages; identified the main educational robotics kits and environments for teaching programming and analyzed the main approaches and methodological strategies for teaching computational thinking and programming in early childhood education. The author ends her research by concluding that there is no consensus on the concepts addressed, and that there are few experiences related to PC development at an early age.

Flores, V. (2019) to obtain his doctoral degree in Systems Engineering, determined how the holistic model of code-literacy allows the development of computational thinking in elementary schoolchildren. To build the holistic model used, the researcher took into account concepts of systems, modeling components and interactions of a system; second-order cybernetics, communication, control and feedback, autopoiesis and pedagogical principles of socio-constructivism and constructionism. After his research, the author concludes that the implemented model allowed the development of computational thinking, at a medium-high level.

Lastra, (2019) designed and implemented unplugged didactic strategies with the objective of developing computational thinking in students in the fifth year of elementary education for his final master's degree in educational informatics for teaching. The research was carried out under the action-research modality in three phases of execution: application of a computational thinking test, classroom intervention with unplugged activities and finally, application of the test again to verify progress in the development of competencies related to computational thinking. The researcher found an improvement in the students' results after his intervention and a relevant advance in their levels of abstraction. Additionally, he concludes that the strategies, sequences and didactic material present the possibility of replication, modification and dissemination in diverse educational contexts.

Bel-Verge, M. and Mon, F. (2019) presented a research where they integrated educational robotics in an early childhood education classroom, for which they developed a design and executed an educational intervention based on the didactic model of Kotsopoulos et al. (2017) and analyzed the suitability of the didactic model of introduction to robotics and development of computational thinking. Within their results they observed that the use of the robot, participation, motivation and classroom climate are precursor factors of learning for infants. Despite the above, the authors state that the project was very limited given the population sample and therefore stress that it is important that this initiative be followed up and evaluated in successive years and that it also be carried out with a larger sample to guarantee its effectiveness and impact at a global level.

Caballero-Gonzalez (2020), developed his doctoral thesis around the design and integration of educational activities based on learning scenarios with programming challenges and educational robotics, whose target population was early childhood schoolchildren. To achieve this, he first conducted a theoretical review on the new literacies for the 21st century and the influence of technologies such as educational robotics in the promotion of new learning and ways of thinking. To achieve this, the researcher organized two study groups under a quantitative approach and a quasi-experimental design. The data collected were analyzed through statistics and it was found that the students who participated in the initiative had significant differences compared to those who did not. It was found that the activities implemented managed social skills and positive behaviors among students and high motivation among them.

Sun, et al. (2020) with the aim of recognizing how computational thinking influences science, technology, engineering and mathematics (STEM) fields and how students' learning attitude is related to the development of computational intelligence conducted two investigations on a population of Chinese children. In the first investigation they validated a STEM learning attitude scale in a sample of 489 students. In the second investigation, they explored the association between such attitude and their computational thinking skills. The researchers found that learning attitude toward STEM significantly predicted computational thinking skills. They also found that girls had higher learning attitudes than boys and that fourth grade could be a key period for the development of such thinking.

Sanchez, V. (2021) analyzes the relationship between robotics, programming and computational thinking in early childhood education, for which she reviews different educational and curricular proposals and discusses the concepts and how they can be worked in the classroom with children under 6 years of age. Among the conclusions reached by the author is that many current proposals are based on extracurricular or isolated activities that are motivating but waste their potential. The researcher suggests that it is necessary to train teachers so that they can apply strategies that favor the development of computational thinking in students.

From the literature consulted that makes up the state of the art of education for the development of computational thinking, the following trends are presented in the following table.

Table 1.

Trends in education research for the development of computational thinking.

Topics	Authors
Gathering ideas on strategies used for the development of computational thinking	1. Segura, J., Mon, F., Llopis, N. y Valdeolivas, N. (2017) 2. González-González (2019)
Teachers' Perceptions of Computational Thinking	1. Corradini, I., Lodi, M. y Nardelli, E (2017)
Development of instruments to measure computational thinking.	1. Román-González, MPérez-González, J.C y Jiménez F. (2017) 2. Arranz de la Fuente, H. y Pérez, A. (2017) 3. Chiazzese, G., Arrigo, M., Chifari, A., Lonati, V. y Tosto C. (2019) 4. Sun, L., Hu, L, Yang, W., Zhou, D. y Wang, X. (2020)
Contributions of unplugged strategies for the development of computational thinking.	1. Delgado, M. y Prado, C. (2018) 2. Lastra, L. (2019)
Contributions of plugged-in strategies for the development of computational thinking.	1. Boticki, I., Pivalica, D. y Seow (2018) 2. Ángel Alsina, Y. (2017) 3. García-Valcárcel y Caballero-González (2018) 4. Chiazzese, G., Fulantelli, G., Pipitone, V. y Taibi, D. (2018) 5. Bel-Verge, M. y Mon, F. (2019) 6. González-González (2019) 7. Flores, V. (2019) 7. Caballero-Gónzalez (2020)
Development or conceptual approach to the idea of computational thinking.	1. Sánchez, V. (2021)

Source: Own elaboration based on a review of the state of the art.

CONCLUSIONS

Several situations can be concluded from the review of the published articles:

a. There is a marked tendency to present experiences related to the use of technologies such as software, computer tutors, robots and video games for the development of computational thinking and, in contrast, a smaller number of publications related to unplugged initiatives, i.e. without the mediation of screens or ICT. This situation arises from the widespread dissemination of the idea that computational thinking is developed by and for the use of computer systems.

b. There is also a relevant trend in the development of instruments for measuring computational thinking and conceptual development of the term since, as mentioned above, it seems that there is no consensus among the scientific community on what this concept means and therefore on how it can be accurately measured.
c. Less published research is observed in initiatives related to unplugged computational thinking development strategies, probably because this concept is usually related to the use and development of technologies.
d. Didactic aspects are among the least studied and are usually focused on activities related to subjects such as technology and mathematics Segura, J., Mon, F., Llopis, N. and Valdeolivas, N. (2017), therefore, there is an opportunity for research in areas other than those named above.
e. There is evidence that seems to indicate that girls have greater facilities for the development of computational thinking as raised by Chiazzese, G., Fulantelli, G., Pipitone, V. and Taibi, D. (2018) in Italy with their work on video game design and by Sun, L., Hu, L, Yang, W., Zhou, D. and Wang, X. (2020).

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