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Computational and algebraic thinking: an analysis of brazilian research

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ABSTRACT

The development of Computational Thinking and Algebraic Thinking is one of the objectives established by the Brazilian National Common Curricular Base (BNCC) for Mathematics education in Basic Education, since both contribute to problem formulation and problem-solving across different areas of knowledge. In this context, it is important to identify the concepts that characterize Algebraic Thinking and Computational Thinking, as well as their relationships and forms of development, based on Brazilian research. This study originated from a bibliographic investigation conducted within the framework of a qualitative approach. Initially, sixteen studies were identified using the keywords "algebra" and "computational thinking." After reading the abstracts, exclusion criteria were established, resulting in a corpus composed of ten studies, including seven master's dissertations and three doctoral theses. The analysis of the material revealed that the authors drew on different theoretical frameworks, organizations, and curricular documents to identify the concepts that characterize these forms of thinking, as well as the ways in which they can be developed. Regarding Algebraic Thinking, most studies highlight generalization and the study of patterns as essential elements for its development. With respect to Computational Thinking, the prevailing understanding is that it corresponds to the mental processes involved in problem formulation and problem-solving, which can be developed with or without the use of computers. Furthermore, the studies identify abstraction, pattern recognition, and generalization as concepts shared by both forms of thinking. The proposed educational practices include unplugged and plugged activities implemented at different educational levels, with an emphasis on the use of block-based programming languages. However, research on this topic remains limited, highlighting the need for further studies that deepen the understanding of the relationships and distinctions between these two forms of thinking, as well as propose activities that can be implemented, particularly in Mathematics classes in Basic Education.

KEYWORDS: Mapping. Patterns. Computational thinking. Unplugged activities. Plugged activities.

1 INTRODUCTION

The development of Computational Thinking (CT) and Algebraic Thinking (AT) is one of the objectives of Mathematics education in Basic Education, as established by the Brazilian National Common Curricular Base (BNCC), since both are cognitive processes aimed at problem formulation and problem-solving across different areas of knowledge, particularly in the understanding and development of digital technologies. It is important to note that, prior to the publication of the BNCC (Brasil, 2018), research on the use of digital technologies in education had already addressed issues related to these forms of thinking, especially those associated with programming (Maltempi, 2024). However, with the emergence of programming communities such as Code.org, Code Academy, and Scratch, the implementation of public policies aimed at incorporating Computer Science concepts into school curricula in different countries (Brackmann, 2017), and the publication of Jeannette Wing's article Computational Thinking in 2006, the scientific community became increasingly engaged in understanding the meaning of Computational Thinking (CT) and in designing educational activities that foster its development (Valente, 2024), particularly those articulated with mathematical concepts and procedures (Perceval *et al*., 2024).

Wing (2016) defines Computational Thinking as the set of mental processes involved in problem formulation and problem-solving through clearly defined procedures that can be executed by both humans and machines. Furthermore, according to the author, Computational Thinking consists of "using abstraction and decomposition when attacking a large and complex task or designing a large and complex system […]. It is choosing an appropriate representation for a problem or modeling the relevant aspects of a problem to make it tractable" (Wing, 2016, p. 2), thereby enabling the construction of an algorithm. The representations used in this process must be clear and precise; therefore, mathematical representations, particularly algebraic representations, are frequently employed.

In an effort to identify the concepts associated with the development of Computational Thinking, researchers, as well as national and international organizations, have highlighted four fundamental elements: **decomposition**, the process of breaking a problem into smaller parts; **pattern recognition**, which involves identifying similarities and characteristics that facilitate efficient problem-solving; **abstraction**, understood as the process of selecting the relevant aspects of a situation; and **algorithms**, defined as a set of instructions designed to solve problems (Brackmann, 2017). The construction of algorithms enables the automation of processes (Savioli, Bianchini, & Lima, 2023). According to the BNCC (Brasil, 2018), algorithms should play a significant role in the school context, becoming an object of study across different subjects in Basic Education, particularly in Mathematics.

The aforementioned document states that "algorithmic language has points in common with algebraic language, especially regarding the concept of variables" (Brasil, 2018, p. 269). From this perspective, algebraic concepts constitute an important tool for solving problems not only in Mathematics but also in different areas of knowledge, particularly in Computer Science. Furthermore, "another algebra-related skill that is closely associated with Computational Thinking is the identification of patterns for establishing generalizations, properties, and algorithms" (Brasil, 2018, p. 271).

The learning of these concepts and the development of Algebraic Thinking (AT), which is one of the goals of algebra instruction, can be fostered through activities involving pattern recognition because "when working with patterns, students are encouraged to extend their reasoning beyond particular cases, promoting the construction of general rules that can be expressed through algebraic language" (Barbosa, Vale, & Gualandi, 2025, p. 5). Thus, Algebraic Thinking is understood as a form of Mathematical Thinking (MT) "that goes beyond the mere manipulation of symbols and equations. It involves the ability to generalize mathematical relationships, identify patterns, and solve problems in an abstract and generalized way" (Barbosa, Vale, & Gualandi, 2025, p. 2), thereby contributing to the development of Computational Thinking (Perceval *et al.*, 2024; Savioli, Bianchini, & Lima, 2023).

From this perspective, promoting the development of Computational Thinking is not limited to the use of computers, software, or programming languages (plugged activities). Rather, it involves designing learning situations that may include physical resources such as pencils, paper, compasses, and rulers (unplugged activities), requiring students to use Computational Thinking to formulate ideas, communicate, solve problems, develop new solutions (Maltempi, 2024), and reason in a structured and critical manner (Savioli, Bianchini, & Lima, 2023).

Given this context, this study aims to identify the concepts that characterize Algebraic Thinking and Computational Thinking, as well as their relationships and the ways in which they can be developed, based on Brazilian research. This type of investigation is particularly relevant because it enables the systematization of the knowledge produced on the topic, highlighting what has already been investigated, who the researchers are, where these studies have been conducted, the advances achieved, and the gaps that still remain. Furthermore, the findings may contribute to teaching practice by providing teachers with evidence to support the selection and design of educational activities aimed at fostering the development of these forms of thinking.

2 METHODOLOGICAL CHOICES

The research that gave rise to this article is grounded in the principles of a qualitative approach. Regarding its methodological procedures, it is characterized as bibliographic research, since it was developed based on previously published material (Gil, 2002). Furthermore, it is classified as a research mapping, as, according to Fiorentini, Passos, and Lima (2016, p. 18), this type of study consists of "a systematic process of identifying and describing information about research produced within a specific field of study."

Data collection was carried out during August 2023 through searches in the Catalog of Theses and Dissertations of the Coordination for the Improvement of Higher Education Personnel (CAPES) and the Brazilian Digital Library of Theses and Dissertations (BDTD). To guide the searches, the following descriptors were used: "algebra" AND "computational thinking." Initially, a search was conducted in the CAPES repository, which identified 14 studies, comprising 11 master's dissertations and three doctoral theses. Subsequently, a search was performed in the BDTD, resulting in 11 studies, including six master's dissertations and five doctoral theses.

It is important to note that eight of the studies identified in the BDTD had already been found in the CAPES repository. In addition, one of these studies appeared twice within the BDTD database itself, resulting in a total of 16 distinct studies, consisting of 11 master's dissertations and five doctoral theses. After reading the abstracts, six studies were excluded because they did not address the relationships between Algebraic Thinking (AT) and Computational Thinking (CT). Consequently, the final corpus comprised ten studies, including seven master's dissertations and three doctoral theses, as presented in Table 1.

Table 1 - Selected studies

P	Author(s)	Year	Title of the study	T	PPG/HEI
1	Mariana O. Pucci	2019	The Use of Scratch for Teaching and Learning First-Degree Algebraic Equations	D	Mathematics in the National Network (PROFMAT) / UFFS
2	Camila Schneider	2020	Computational Thinking and Its Contributions to the Study of Algebra in Elementary Education	D	Science and Mathematics Education / PUC-RS
3	Emerson B. Corrêa	2020	The Development of Computational and Algebraic Thinking in the Initial Education of Mathematics Teachers: A Case Study Using Scratch	D	Science Teaching and Mathematics Education / UEPG
4	Rodrigo Duda	2020	Using the App Inventor Platform from a Constructionist Perspective as a Strategy for Fostering Algebraic Thinking	T	Science and Technology Education / UTFPR
5	Ana Paula Canal	2021	Computational Thinking Integrated with Problem Solving in the Initial Education of Mathematics Teachers: An Approach Based on Robbie Case's Theory	T	Science and Mathematics Education / UFN
6	Eloisa R. Navarro	2021	The Development of the Concept of Computational Thinking in Mathematics Education According to the Contributions of Historical-Cultural Theory	T	Education/ UFSCar
7	Izamara R. Ramos	2021	SCR-Algebra: A Flipped Learning Environment for Developing Computational and Algebraic Thinking	D	Science Teaching and Mathematics Education / UEPB
8	Mariana M. Okamoto	2021	Processes and Subprocesses of Advanced Mathematical Thinking Identified in Computational Thinking Skills	D	Mathematics Education / PUC-SP
9	Allan José	2022	Mathematical Thinking and Computational Thinking in Problem Solving: An Analysis of	D	Mathematics Education / UNESPAR

			a Problem Statement in a Distance Learning Course		
10	Luanna B. A. Ribeiro	2022	Computational and Mathematical Thinking: A Study of Pre-service Teachers' Knowledge for Teaching Sequences	D	Science Teaching and Mathematics Education / UEPB

Source: Research data (2023).

Note: Column P – study identification number; Column T – Doctoral Thesis (T) or Master's Dissertation (D).

To systematize and analyze the information extracted from the mapped studies, a data extraction form, adapted from Fiorentini, Passos, and Lima (2016), was developed. The form included the following elements: research problem, research question, objectives, methodological procedures, theoretical frameworks, results, and conclusions. Based on this data extraction form, the following analytical criteria were established: (i) the theoretical approach(es) used to characterize Algebraic Thinking (AT) and Computational Thinking (CT); (ii) the fundamental concepts identified for characterizing and developing Algebraic Thinking and Computational Thinking; and (iii) the actions developed by the authors of the mapped studies aimed at promoting the integrated development of Algebraic Thinking and Computational Thinking.

3 RESULTS AND DISCUSSION

The data presented in Table 1 indicate that the first studies on this topic were conducted in 2019, followed by studies published in 2020, 2021, and 2022. This finding may be associated with the publication of the Brazilian National Common Curricular Base (BNCC) (Brazil, 2018), since Computational Thinking (CT) has received increasing attention in Brazil following the dissemination of this document (Valente, 2024). The studies were conducted at nine Higher Education Institutions (HEIs) located in only three Brazilian states. The Southern Region accounts for the largest number of studies, totaling six investigations (P1, P2, P3, P4, P5, and P9), distributed across the states of Paraná, with three studies (UEPG, UNESPAR, and UTFPR); Rio Grande do Sul, with two (PUC-RS and UFN); and Santa Catarina, with one (UFFS). The remaining studies are distributed between the Southeastern Region, with two investigations (P6 and P8) conducted at PUC-SP and UFSCar, and the Northeastern Region, also with two studies (P7 and P10), both conducted at the State University of Paraíba (UEPB). It is noteworthy that the State University of Paraíba (UEPB) is the only institution outside the Southern Region that has produced two studies on this topic. Furthermore, study P1 is the only one originating from the National Network Professional Master's Program in Mathematics (PROFMAT), conducted at the Federal University of Fronteira Sul (UFFS). Regarding the remaining studies, five belong to the field of Teaching, whereas four are associated with the field of Education.

Table 2 presents the main theoretical frameworks related to Algebraic Thinking (AT) cited in the mapped studies. It should be noted that all publication years of the referenced works identified in the studies were considered. However, this does not imply that each study used all of these editions. Therefore, the complete references can be found in the studies presented in Table 1.

Table 2 - Main theoretical frameworks related to Algebraic Thinking (AT)

Authors	Studies
Blanton; Kaput (2005)	P1; P3; P4; P5; P8; P10
Radford (2006, 2008, 2009, 2010, 2011, 2014, 2018, 2021)	P3; P4; P6; P7
Kaput (1999, 2000, 2005, 2007, 2008)	P3; P4; P6; P7
BNCC (BRASIL, 2018)	P1; P2; P10
Fiorentini; Miorim; Miguel (1993)	P4; P7
Van De Walle (2009)	P6; P10
Lins (1994)	P9

Source: Research data (2023).

The data presented in Table 2 indicate that several scholars dedicated to investigating the concepts that characterize Algebraic Thinking (AT) and the ways in which it can be developed were cited by the authors of the mapped studies. Among them, Maria L. Blanton, James Kaput, and Luis Radford stand out as the most frequently cited. It is worth noting that although the Brazilian National Common Curricular Base (BNCC) (Brasil, 2018) does not explicitly address Algebraic Thinking, three studies adopted this document as a theoretical framework, particularly study P2, which does not rely on other authors for its theoretical foundation.

The authors of studies P1, P3, P4, P5, P8, and P10 draw on the contributions of Maria L. Blanton and James Kaput, whereas the authors of P3, P4, P6, and P7 also build upon the ideas of Luis Radford. According to these scholars, Algebraic Thinking refers to the process of generalizing relationships present in quantitative and non-quantitative situations through the use of different forms of representation, such as natural, figural, symbolic, and algebraic languages. Furthermore, they argue that pattern identification and generalization are fundamental strategies for the development of this form of thinking. In turn, Luis Radford, cited in studies P3, P4, P6, and P7, argues that Algebraic Thinking does not develop spontaneously, since it corresponds to a sophisticated form of reflection and action that has been historically constructed and refined over time until it acquired its current characteristics.

Studies P1, P2, and P10 refer to the BNCC (Brasil, 2018), emphasizing that the document does not provide an explicit definition of Algebraic Thinking. Nevertheless, it establishes that the purpose of Algebra is to foster the development of this particular form of thinking, which is essential for using mathematical models to understand, represent, and analyze quantitative relationships among quantities through the use of letters and other mathematical symbols. Based on this document, the authors emphasize the importance of introducing Algebra from the early years of Elementary Education, with particular emphasis on exploring regularities and patterns.

Drawing on the perspective of Dario Fiorentini, Maria Ângela Miorim, and Antonio Miguel, the authors of studies P4 and P7 emphasize that there is no single way of expressing Algebraic Thinking. Accordingly, this form of thinking may be manifested through natural, arithmetic, and geometric languages or through the construction of a specific language, namely, a purely symbolic algebraic language. From this perspective, Algebraic Thinking consists of using symbolic language to describe, model, and solve problems, thereby promoting processes of generalization.

Based on the contributions of John A. Van de Walle, the authors of studies P6 and P10 advocate proposing activities involving patterns as a strategy for developing Algebraic Thinking, arguing that learning to identify, describe, extend, and generalize patterns constitutes an essential part of doing mathematics and of algebraic thinking. Study P9, in turn, is grounded in the ideas of Romulo Campos Lins, who understands Algebraic Thinking as a way of attributing meaning to Algebra. According to this author, this form of thinking is activated when students identify regularities in arithmetic operations and understand the different functions performed by letters, such as representing an unknown in equations or a variable in functions.

Overall, there is a convergence among the conceptions of Algebraic Thinking presented by the different theoretical frameworks adopted in the mapped studies. Collectively, these authors characterize Algebraic Thinking as a form of Mathematical Thinking that emerges from the processes of generalization established during problem-solving and from the use of progressively more formal mathematical language. To foster its development, they emphasize the importance of proposing activities based on pattern identification, since such activities enable students to observe, analyze, and generalize relationships through different forms of representation, creating an environment conducive to problem-solving and, consequently, establishing connections with Computational Thinking (CT). These findings are consistent with the perspectives advanced by Barbosa, Vale, and Gualandi (2025) and Perceval *et al.* (2024) regarding the concepts that characterize Algebraic Thinking and the ways in which it can be developed.

Table 3 presents the main theoretical frameworks related to Computational Thinking (CT) cited in the mapped studies. It should be noted that the complete references can be found in the studies presented in Table 1.

Table 3 - Main theoretical references related to CT

Authors	**Studies**
Wing (2004, 2006, 2007, 2008, 2010, 2011, 2014, 2017)	P1; P2; P3; P4; P5; P6; P7; P8; P9; P10
Papert (1980, 1985, 1988, 1993, 1994, 1996, 1997, 2008)	P1; P2; P3; P4; P5; P6; P7; P8; P9
Brackmann (2017)	P1; P2; P3; P8; P9; P10
BNCC (BRASIL, 2017, 2018)	P1; P4; P5; P6; P8; P10
Valente (1993, 1996, 1997, 1999, 2002, 2005, 2016, 2017)	P2; P3; P4; P5; P6
Selby; Woollard (2010, 2013, 2014)	P3; P8; P10
Csizmadia *et al.* (2015)	P4; P7
Blikstein (2008)	P5; P6
Barr e Stephenson (2011)	P6; P7
Mestre (2017, 2019)	P6; P10

Source: Research data (2023).

It was found that all the mapped studies drew on the contributions of Jeannette Marie Wing, who defines Computational Thinking (CT) as the mental processes involved in formulating problems and expressing their solutions in such a way that they can be carried out by either a human or a machine. From this perspective, computational thinking is not limited to the act of programming; rather, it is fundamentally a process grounded in abstraction. As highlighted by the authors of the mapped studies, Wing (2006, p. 4) states that CT is "a fundamental skill, not a rote skill. A fundamental skill is something every human being should know in order to function in modern society. A rote skill means mechanical routine."

Seymour Papert's perspective on CT, although the term Computational Thinking was not explicitly used by the author, was mentioned in studies P1, P2, P3, P4, P5, P6, P7, P8, and P9. The authors emphasize that Papert criticized the use of computers merely as tools for transmitting information to children. Instead, he argued that computers should be used as instruments for knowledge construction. Accordingly, CT is associated with the use of computers to construct ideas that are explanatory and accessible, helping people analyze and better understand problems and their possible solutions. It is worth noting that Maltempi (2024) and Valente (2024) continue to advocate the principles proposed by Papert when designing learning activities aimed at fostering the development of CT. The authors of studies P1, P2, P3, P8, P9, and P10 drew on the work of Christian Puhlmann Brackmann, who defines CT as:

> a distinct human creative, critical, and strategic ability to apply the fundamentals of Computer Science across the most diverse fields of knowledge in order to **identify and solve problems**, individually or collaboratively, **through clear steps**, so that they can be effectively executed by either a person or a machine" (Brackmann, 2017, p. 29, emphasis added).

In an effort to characterize CT, studies P1, P4, P5, P6, P8, and P10 referred to the Brazilian National Common Curricular Base (BNCC) (Brasil, 2018). The document states that CT "involves the abilities to understand, analyze, define, model, solve, compare, and automate problems and their solutions in a methodical and systematic manner through the development of algorithms" (Brasil, 2018, p. 474, emphasis added). According to the BNCC (Brasil, 2018), and as evidenced in the mapped studies, these abilities can be developed, particularly in Mathematics classes, through learning processes such as problem-solving, inquiry, project development, and mathematical modeling.

Based on the contributions of José Armando Valente, the authors of studies P2, P3, P4, P5, and P6 explain that the integration of CT as a cross-curricular theme is still in the process of consolidation, since the absence of a consensual definition of this form of thinking hinders its implementation. Nevertheless, these authors argue that CT can foster dialogue between Mathematics Education and digital technologies, serving as a means of "thinking with and thinking about thinking," a perspective that aligns with the ideas proposed by Seymour Papert and revisited by Maltempi (2024).

Studies P3, P8, and P10 were based on the contributions of Cynthia Selby and John Woollard, who understand CT as a cognitive process aimed at problem-solving, involving skills related to abstract thinking, algorithmic reasoning, evaluation, and generalization. The ideas of Andrew Csizmadia and collaborators appear in studies P4 and P7, in which CT is understood as a cognitive process involving logical reasoning for problem-solving.

Drawing on the perspective of Paulo Blikstein, the authors of studies P5 and P6 understand CT as a means of expanding human cognitive and operational capabilities—that is, as a way of using computers to enhance productivity, inventiveness, and creativity. The authors of studies P6 and P7 draw on the ideas of Valerie Barr and Chris Stephenson to emphasize that CT is associated with the use of computers and with thinking with technology. Based on the contributions of Palloma Alencar Alves Mestre, the authors of studies P6 and P10 understand CT as an approach that promotes the application of computational skills in contexts that extend beyond Computer Science, conceiving it as a tool for problem-solving across different areas of knowledge, as also argued by Perceval *et al.* (2024), Maltempi (2024), and Valente (2024).

The analysis of the mapped studies reveals the absence of a consensus regarding the definition of Computational Thinking. This finding may be explained by the different theoretical and practical perspectives adopted across the studies (Valente, 2024). Furthermore, both the scholars cited and the authors of the mapped studies recognize that a more precise definition of CT could help guide the work of teachers in Basic Education. From this perspective, the studies drew on international organizations such as the International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA), as well as national organizations such as the Brazilian Computer Society (SBC) and the Center for Innovation in Brazilian Education (CIEB), in addition to researchers whose work focuses on the integration of Computer Science into Basic Education, with the aim of identifying the concepts involved in this way of thinking. Table 4 presents the concepts considered fundamental to the development of Computational Thinking by the authors of the mapped studies, as well as the theoretical approaches used to support them.

Table 4 - Fundamental concepts for the development of Computational Thinking (CT)

<table>
<tr><th>Concepts</th><th>Theoretical Frameworks</th><th colspan="2">Cited</th><th colspan="2">Revisited in the analysis</th></tr>
<tr><td>Abstraction, automation and analysis.</td><td>SBC (2019)</td><td colspan="2">P8</td><td colspan="2"></td></tr>
<tr><td rowspan="6">Abstraction, decomposition, pattern recognition (identification) and algorithms.</td><td>Brackmann (2017)</td><td colspan="2">P1</td><td rowspan="2">P2</td><td>P10</td></tr>
<tr><td>BBC Learning (2015)</td><td colspan="2"></td><td rowspan="2">P7</td></tr>
<tr><td>Csizmadia et al. (2015)</td><td colspan="2"></td><td>P4</td></tr>
<tr><td>Brackmann et al. (2017)</td><td colspan="2">P3</td><td colspan="2"></td></tr>
<tr><td>CIEB (2018)</td><td colspan="2">P8</td><td colspan="2"></td></tr>
<tr><td>Dantas (2021)</td><td colspan="2"></td><td colspan="2">P9</td></tr>
<tr><td rowspan="3">Data collection, data analysis, data representation, problem decomposition, abstraction, algorithms and procedures, automation, parallelization and simulation.</td><td>CSTA; ISTE; NSF (2011)</td><td colspan="2"></td><td colspan="2" rowspan="2">P5</td></tr>
<tr><td>Barr e Stephenson (2011)</td><td>P3</td><td rowspan="2">P6</td></tr>
<tr><td>ISTE; CSTA (2011)</td><td></td><td colspan="2"></td></tr>
</table>

Source: Research data (2023).

The data presented in Table 4 reveal that the authors of the mapped studies adopted different theoretical frameworks to idetify the concepts considered relevant to the development of Computational Thinking (CT). This finding is consistent with Valente (2024), who highlights that researchers and organizations have made considerable efforts to identify the fundamental concepts that characterize CT. Study P8 was based on the concepts proposed by the Brazilian Computer Society (SBC, 2019), namely: (a) abstraction, understood as a means of modeling and representing information and processes for the development of algorithmic solutions; (b) automation, corresponding to the execution of the developed algorithm by machines; and (c) analysis, referring to the evaluation of the solutions produced in terms of their efficiency. It should be noted that this study also presents the perspectives of the Reference Curriculum in Technology and Computing (CIEB); however, the author does not revisit any of these perspectives during the data analysis.

Most authors of studies P1, P2, P3, P4, P7, P8, P9, and P10 drew on the perspectives of Christian Puhlmann Brackmann and collaborators, BBC Learning, Andrew Csizmadia and collaborators, the Center for Innovation in Brazilian Education (CIEB), and Sérgio Carrazedo Dantas, who identify the following as the fundamental concepts of CT: (a) decomposition, which consists of breaking a complex problem into smaller and more manageable parts; (b) pattern recognition or pattern identification, which makes it possible to analyze each of these parts in greater depth and recognize similar problems that have already been solved; (c) abstraction, aimed at identifying the most relevant aspects of a situation; and (d) algorithms, understood as a set of steps or rules designed to solve the identified subproblems. It is noteworthy that studies P2, P4, P7, P9, and P10 revisit these four concepts during data analysis, emphasizing that their use makes problem-solving more efficient by enabling the decomposition of problems into smaller parts, focusing on relevant information, identifying patterns, and developing strategies for their solution. In contrast, in studies P1, P3, and P8, these concepts are presented only in the theoretical framework and are not revisited during the analysis. It is also worth noting that study P3 refers both to these four concepts and to those proposed by Barr and Stephenson.

The perspective adopted by Valerie Barr and Chris Stephenson, the *Computer Science Teachers Association* (CSTA), the *International Society for Technology in Education* (ISTE), and the *National Science Foundation* (NSF), used by the authors of studies P3, P5, and P6, identifies nine concepts related to CT: (a) data collection and data analysis, referring to the collection and appropriate organization of information; (b) problem decomposition; (c) abstraction; (d) algorithms; (e) automation; (f) simulation, understood as the representation or modeling of processes or products; (g) debugging, related to reviewing and refining the solutions developed; and (h) parallelization or generalization, corresponding to the application of the same procedure to solve different but similar problems. Among the concepts proposed by these authors and organizations, four converge with those identified in the other theoretical frameworks: pattern recognition (represented by data collection and analysis), decomposition, abstraction, and algorithms. Thus, the nine concepts proposed primarily by the international organizations (ISTE and CSTA) provide a more detailed description of the problem-solving process, including the use of computers. However, among the mapped studies, only P5 effectively revisits these concepts during data analysis.

An analysis of the set of fundamental concepts for the development of CT presented in the mapped studies shows that abstraction is present in all definitions. According to Wing (2008), this concept constitutes an essential component of Computational Thinking. Likewise, algorithms appear in every approach, as they represent a fundamental element both for problem-solving and for Computer Science itself. It should also be noted that the concept of algorithms is directly related to the concept of automation, proposed by the Brazilian Computer Society (2019), and to the Computational Thinking competencies established by the Brazilian National Common Curricular Base (Brasil, 2018), since algorithms are the means through which the problem-solving process can be automated (Savioli, Bianchini, & Lima, 2023). Furthermore, most of the mapped studies identify abstraction, pattern recognition, decomposition, and algorithm design as the essential concepts of CT. However, although these concepts are widely discussed in the theoretical framework, they are only minimally explored—or, in some cases, not revisited at all—during data analysis. This suggests that the difficulty in defining CT stems largely from its broad and dynamic nature, the historical relationship between Computer Science and Mathematics (Maltempi, 2024), and its close relationship with other forms of thinking, particularly algorithmic thinking and Algebraic Thinking. However, one can use

> the lenses of Computer Science to highlight and analyze phenomena, thereby establishing new relationships with them through concepts or ideas employed in Computer Science. This perspective is open to connections between Computer Science and other fields of knowledge, aiming at integrating Computational Thinking into both the curriculum and everyday life (Maltempi, 2024, p. 11, emphasis in the original).

Within this context, Computational Thinking can be understood as a set of cognitive processes involved in problem formulation and problem-solving, constituting a way of "forging more accessible and more powerful ideas" (Maltempi, 2024, p. 11) when dealing with situations arising from everyday life or from different fields of knowledge. Consequently, its integration into the school curriculum can take place across various subjects, particularly Mathematics. Considering that the BNCC (Brasil, 2018) establishes the development of CT as one of the objectives of Mathematics education, both Mathematical Thinking (MT) and Computational Thinking (CT) may be understood as cognitive processes aimed at problem-solving, involving abilities such as understanding, analyzing, defining, modeling, and comparing situations. Furthermore, both share common elements in their respective languages—algorithmic and algebraic—particularly with regard to the use of variables, pattern recognition, and generalization. Therefore, it becomes relevant to examine the actions developed by the authors of the mapped studies to promote the integrated development of Algebraic Thinking (AT) and Computational Thinking (CT).

Table 5 presents the level of education (LE) (Elementary Education (EE), Secondary Education (SE), Higher Education (HE)) in which the actions were carried out, the mathematical content addressed, and the way in which concepts related to PA and CT were explored (plugged activities; unplugged activities). It is noted that P6 and P8 are not indicated, as they are bibliographic studies.

Table 5 - Actions developed to promote the development of Algebraic Thinking (AT) and Computational Thinking (CT)

P	LE	Mathematical Content	Plugged Activities	Unplugged Activities
1	EE	First-Degree Algebraic Equations	Scratch	Solving problem situations using paper and pencil
2	EE	Algebraic Expressions	Excel	Creating spreadsheets using paper, pencil and ruler
3	HE	Polygons	Scratch	Constructing polygons using paper, pencil, ruler and compass
4	H	First-Degree Equations	App Inventor	Recording ideas for algorithm development on paper
5	HE	Sequences and Figurate Numbers	Python	Activities involving the Turing Machine
7	EE	Algebraic Expressions	Scratch	Solving problem situations using paper and pencil
9	-	Matrices	GeoGebra	-
10	HE	Numerical and Non-numerical Sequences	-	Solving problem situations using paper and pencil

Source: Research data (2023).

Regarding the educational level at which the activities were implemented in the mapped studies (Table 5), it is observed that the authors of studies P1, P2, and P7 worked with classes from the final years of Elementary Education, whereas the author of P4 conducted the activities at the High School level. Based on these findings, it is evident that most of the studies focused on the final years of Elementary Education, with no studies addressing the early years of this educational stage and only one study directed toward High School. Because P9 consisted of a teacher education course, it did not specify the participants' educational level, as it involved students from different levels of schooling. Studies P3, P5, and P10, in turn, were conducted in Higher Education. These studies reveal the authors' concern with understanding participants'—future teachers'—conceptions of Algebraic Thinking (AT) and Computational Thinking (CT), as well as the ways in which these forms of thinking can be developed. This concern is justified by the importance of understanding these concepts for implementing consistent pedagogical practices in Basic Education, as advocated by researchers (Brackmann, 2017; Maltempi, 2024; Valente, 2024), national and international organizations (CSTA; ISTE; NSF, 2011; SBC, 2019; CIEB, 2018), and official policy documents (Brasil, 2018).

With regard to the mathematical content explored in the studies, P1 and P4 focused on algebraic equations; P2 and P7 explored algebraic expressions; P5 and P10 investigated numerical and non-numerical sequences; and P9 addressed the topic of matrices. It is worth noting that, although P3 explored geometric concepts, it was included in the mapping because its guiding research question was: "Which aspects of Computational Thinking and Algebraic Thinking are evidenced by pre-service Mathematics teachers while carrying out activities using Scratch?" (Corrêa, 2020, p. 17). The selection of these mathematical topics can be explained by the central role that algebraic language plays in the formulation of generalizations, an aspect shared by both Algebraic Thinking and Computational Thinking, as highlighted by the BNCC (Brasil, 2018), Savioli, Bianchini, and Lima (2023), and

Perceval *et al.* (2024). Another common element explored across the studies is pattern recognition, particularly through numerical and non-numerical sequences.

Only one study did not include plugged activities, that is, activities requiring the use of computers. This finding corroborates Valente's (2024) assertion that, although there are numerous and diverse pedagogical possibilities for fostering CT, most studies still rely on digital technologies, particularly programming languages. Block-based programming languages were adopted in four of the eight studies analyzed (P1, P3, P4, and P7). In this context, the use of block-based programming languages, such as Scratch, is understood to promote intuitive and easy-to-understand visual interfaces, making them particularly suitable for Basic Education (Valente, 2024). Furthermore, these tools enable students to develop interactive projects, such as games and stories, stimulating creativity while fostering the development of both Computational Thinking and Algebraic Thinking, insofar as they encourage problem-solving strategies across different areas of knowledge (Savioli, Bianchini, & Lima, 2023).

Most of the authors of the mapped studies chose to combine plugged and unplugged activities. Studies P1, P3, and P7, for example, developed activities using physical materials such as pencils, paper, rulers, and compasses, combined with the use of the Scratch block-based programming language. In study P1, unplugged activities were initially proposed with the aim of investigating students' difficulties related to first-degree algebraic equations, particularly regarding their understanding of the role played by letters in different contexts—that is, when they represent an unknown and when they represent a variable, a distinction considered fundamental to the development of both Algebraic Thinking and Computational Thinking (Brasil, 2018). Subsequently, the Scratch programming blocks were introduced, and students were asked to use them to solve the following problem situation:

> The eighth-grade students decided to have T-shirts made for the school competition. The clothing manufacturer will charge a fixed fee of R$15.00 plus R$23.00 for each T-shirt produced. If 30 students in this class order T-shirts [...], how many reais will the class have to pay? (Pucci, 2019, p. 54).

According to the author of study P1, this activity enabled students to identify both similarities and differences between algebraic language and the programming language used in Scratch. Among the similarities, the most notable were pattern recognition and the formulation of generalizations. In other words, students recognized that the total amount paid (TP) corresponds to the sum of a fixed amount of $R\$ \ 15.00$ plus an additional $R\$ \ 23.00$ for each T-shirt (x) ordered, which can be represented by the algebraic expression $TP = 15 + 23x$. To solve the proposed problem, it is sufficient to substitute the variable x with the value 30. As for the differences, students identified the need to correctly select the programming blocks capable of representing this algebraic expression within the Scratch environment.

Study P3 initially proposed the construction of polygons (squares and triangles) through unplugged activities, using pencils, paper, rulers, and compasses. Subsequently, these constructions were reproduced in Scratch. According to the author of study P3, "programming a square in Scratch requires the mobilization of several algebraic and computational skills" (Corrêa, 2020, p. 99). The algebraic skills referred to by the author are understood to be primarily related to abstraction, pattern recognition, and generalization, concepts regarded as fundamental to the development of Algebraic Thinking (AT) (Barbosa, Vale, & Gualandi, 2025) and likewise essential for constructing geometric figures in Scratch. This is because designing an algorithm to construct a square requires students to understand that this figure is a regular quadrilateral whose sides are equal in length and whose interior angles measure 90°. Accordingly, the sprite (the term used in Scratch) always travels the same distance—for example, by using the "move 100 steps" block—and performs a constant rotation using the "turn 90° clockwise" block, repeating this sequence of commands until the four sides of the figure have been completed, a process that clearly illustrates pattern recognition. However, this procedure can be simplified when students increase their level of abstraction and generalize the construction process. This occurs, for example, when the "ask" block is used to prompt the user for the length of the square's side and stores this information in a variable (represented by the "answer" block).

The author of study P7 began her proposal with unplugged activities, presenting problem situations designed to investigate students' prior knowledge of algebraic expressions. Subsequently, plugged activities were developed using the SCR-Algebra learning environment, created with the Scratch programming language. According to the author, the implementation of these activities

> provided the participating students with a space to express their difficulties and strengths and to use Computational Thinking skills, such as **Pattern Recognition** and **Abstraction**, to enhance their levels of Algebraic Thinking, promoting meaningful learning of the topic of algebraic expressions" (Ramos, 2021, p. 132, emphasis added).

It can be observed that the mobilization of Computational Thinking concepts, particularly abstraction and pattern recognition, emerged as an important resource for the construction of meaning and the development of Algebraic Thinking. This finding is consistent with the discussions presented by Savioli, Bianchini, and Lima (2023) and Perceval *et al.* (2024), who argue for the close relationship between these two modes of thinking. A block-based programming language was also employed in study P4, which adopted App Inventor because of its ability to support the development of applications for Android mobile devices. Before and during the work with this tool, students used pencils and paper to organize and record their ideas before writing the code (algorithms). Regarding the concepts of Computational Thinking, the author explains that they

> are implicit throughout the entire application development process. **Abstraction** in the students' actions is evidenced by the infrequent use of written records on paper to structure the computational **algorithms**. Likewise, **decomposition** and **pattern recognition** are reflected in the problem-solving process and in the expression of regularities that structure the algorithms" (Duda, 2020, p. 126, emphasis added).

Furthermore, the intentional use of algebraic representations to express solutions in a manner that can be understood by both humans and machines constitutes a characteristic indication of the integration of concepts related to Algebraic Thinking (AT) and Computational Thinking (CT). According to the author, the use of App Inventor represents an alternative for contextualizing the application of Algebra to mathematical problem-solving while fostering the development of CT, since "students are not merely reproducing previously acquired knowledge but are simultaneously engaging in the practice of generalization and the practice of 'thinking computationally'" (Duda, 2020, p. 120). The *Python* programming language, considered more advanced than block-based programming languages, was the option adopted by the author of study P5, who also developed unplugged activities using the Turing Machine. One of the proposed activities involved constructing the Fibonacci sequence. To accomplish this, the pre-service teachers were asked to answer the following questions: How many pairs of rabbits will there be after two, three, and four months? How many pairs of rabbits will there be in the tenth month? Is it possible to represent this sequence mathematically? If so, how? According to the author, this activity enabled the pre-service teachers to understand the definition of a recursive sequence and, based on this understanding, to develop a recursive algorithm in Python. To construct their solutions, the participants

> needed **to collect** the relevant **data** from the problem, which was presented in descriptive form. They sought **relationships among the data**, engaged in **abstraction**, **tested conjectures**, until the existing pattern was identified (data analysis). To achieve **generalization**, abstraction was essential when determining the equations of the Fibonacci sequence. The resulting definition was recursive. The skill of algorithms and procedures was evident as they developed and implemented the **algorithm** to generate the numerical sequence. Because the function was implemented recursively, the problem was **decomposed** into smaller parts—for example, the two base cases, when n = 1 and n = 2 (problem decomposition), while the remaining elements of the sequence were generated recursively according to the definition based on the sum of the two preceding elements" (Canal, 2021, p. 161, emphasis added).

According to the author of study P5, the connections established by the pre-service teachers between the concepts of Algebraic Thinking and Computational Thinking justify the relevance of an educational approach that integrates these two modes of thinking across all levels of education, as advocated by the BNCC (Brasil, 2018). Furthermore, the author emphasizes the importance of pattern recognition and generalization, since these processes involve abstracting common characteristics for the development of algorithms while encompassing aspects related to data storage, data input, data output, and problem-solving strategies. Studies P2 and P9 opted to use programmable software, specifically Microsoft Excel and GeoGebra, respectively. The author of study P2 proposed the construction of spreadsheets designed to calculate students' grade averages across different school subjects. Initially, the required calculations were carried out using pencil and paper. Subsequently, these same procedures were implemented in a spreadsheet developed in Microsoft Excel. According to the author, this initial stage

> proved to be highly meaningful because it was at this moment that the participants reflected on the concepts of Computational Thinking (without using a computer); that is, they considered how they perceived the **decomposition** of the spreadsheet, where the **patterns** were located, and which information was less relevant so that, through **abstraction**, they could develop the **algorithm**, which constituted the solution to the problem. This spreadsheet served as the basis for implementation in the Excel software. Thus, it is understood that it was during this stage that they developed the solution to the problem" (Schneider, 2020, p. 56, emphasis added).

Based on the analysis of the activities developed using Microsoft Excel, the author found that the students identified connections between Algebraic Thinking (AT) and Computational Thinking (CT) by formulating and testing conjectures, establishing relationships, identifying patterns, and making generalizations, as well as by associating algebraic expressions with the algorithms they had constructed. This finding corroborates the conclusions of Savioli, Bianchini, and Lima (2023, p. 144), who argue that Excel "proves to be a potential tool for fostering Computational Thinking, while also promoting a close relationship between this mode of thinking and Algebraic Thinking."

Study P9 analyzed the responses provided by participants in an online course to a problem situation involving the encoding of messages through matrix multiplication, using the GeoGebra software, specifically its Computer Algebra System (CAS) View. The choice of this tool is justified by its ability to perform symbolic computations through spreadsheet-like cells, each of which contains an input field at the top and displays a sequential record of the operations performed after each command is entered (José, 2022). According to the author, this problem situation was selected because it was expected to "encourage participants to make greater use of both Mathematical Thinking and Computational Thinking during the problem-solving process" (José, 2022, p. 43). According to the author of study P9, Mathematical Thinking (MT) involves cognitive processes related to the abilities to represent, generalize, visualize, classify, analyze, formulate conjectures, reason inductively, formalize, and abstract. These same abilities are also identified in the mobilization of Computational Thinking, since this mode of thinking

> establishes a way of organizing thought that develops and systematizes (even if unintentionally) important life skills, such as decomposing problems, thinking recursively, recognizing patterns, identifying regularities and irregularities, abstracting relevant elements, generalizing processes, developing algorithmic strategies, constructing explanatory and representative models, incorporating concepts from fields beyond Computer Science, and articulating symbols and codes, among others (José, 2022, p. 32).

The analysis of the solutions produced by the participants showed that traces of Mathematical Thinking and Computational Thinking intertwine and "move in similar directions during the production of reasoning, sharing common aspects and elements, although they are not necessarily identical" (José, 2022, p. 91). According to the author of study P9, this relationship may become so close that, in certain situations, it is difficult to distinguish the mobilization of each of these modes of thinking, as is the case with abstraction. It should be noted that this observation is also reported by Maltempi (2024), further reinforcing the close relationship between these cognitive processes.

Study P10 opted to develop unplugged activities, exploring numerical and non-numerical sequences, a mathematical topic identified by the BNCC (Brazil, 2018) as particularly suitable for integrated work with Computational Thinking, especially through the construction of algorithms represented by flowcharts. According to the author, working with sequences requires the mobilization of fundamental concepts of Algebraic Thinking, such as abstraction, pattern recognition, and generalization, as well as concepts of Computational Thinking, including decomposition, abstraction, pattern recognition, and algorithms. When explaining the solution to the following problem situation:

> The eighth element of a sequence is 20. What could be the algebraic expression for the general term? It is necessary to think about the **decomposition** of the sequence, in which only one term is known, identifying the number 20 as its eighth element. Next, we must **abstract** the fact that the preceding terms are unknown, focusing our attention on the known term and its position: 20 is the term in the eighth position. We then seek to **establish a pattern** relating the two numbers that indicate the term's position and the term itself (8 and 20, respectively), **generalizing** this relationship to any position n through an **algorithmic** procedure for generating the terms of the sequence" (Ribeiro, 2022, p. 74, emphasis added).

According to the author of study P10, Computational Thinking (CT) is an essential skill for solving complex problems, whose applicability extends to a wide range of contexts, regardless of the nature or complexity of the situation under analysis. Its core concepts are aligned with skills that can be developed in conjunction with the mathematical content taught in Basic Education, particularly that related to Algebra, as indicated by the Brazilian National Common Curricular Base (BNCC) (Brasil, 2018) and Perceval *et al.* (2024). The author further emphasizes that living in a society in which the ability to access, process, and manage information has become increasingly important requires the development of skills such as abstraction, generalization, and creative thinking, which are fundamental for enabling students to act critically and contribute to the construction of a more just and equitable society.

Within this context, the findings of the mapped studies reveal important connections between Algebraic Thinking (AT) and Computational Thinking (CT), particularly with regard to the mobilization of processes such as abstraction, pattern recognition, and generalization, as also highlighted by Savioli, Bianchini, and Lima (2023) and Perceval *et al.* (2024). Furthermore, the analyzed studies reinforce the importance of integrating plugged and unplugged activities in the development of CT. With respect to plugged activities, block-based programming languages stand out, particularly when working with Elementary Education students, as they facilitate the understanding of computational concepts in an accessible and intuitive manner. Regarding unplugged activities, the studies highlight the importance of proposing situations in which students are challenged to identify patterns and regularities, since this ability provides the foundation for establishing generalizations, properties, and algorithms. Thus, both types of activities complement one another in fostering the development of Algebraic Thinking and Computational Thinking, strengthening the relationship between these two modes of thinking and demonstrating their potential to enhance Mathematics education in Basic Education.

4 FINAL CONSIDERATIONS

The analysis of the mapped studies revealed that the authors drew on different national and international theoretical frameworks, as well as curriculum documents, to identify the concepts that characterize Algebraic Thinking (AT) and Computational Thinking (CT) and the ways in which these forms of thinking can be fostered in educational contexts. With regard to Algebraic Thinking, the findings indicate that it is understood as a way of thinking mathematically that supports the understanding of Algebra by enabling students to generalize mathematical ideas through different forms of representation, including natural language, schematic representations, and algebraic language. Its development can be promoted through activities involving patterns and regularities, since these strategies enable students to observe, analyze, and generalize mathematical relationships, thereby promoting greater student agency in the learning process and strengthening their problem-solving abilities.

Regarding Computational Thinking, the findings indicate that its definition is still undergoing a process of consolidation. Nevertheless, the studies analyzed converge in recognizing its importance for developing abilities such as abstraction, creativity, strategy formulation, argumentation, and problem-solving—competencies that are increasingly essential in a society profoundly shaped by digital technologies. From this perspective, Computational Thinking can be understood as a set of cognitive processes involved in problem formulation and problem-solving, which may be developed through both plugged and unplugged activities. Among the concepts most frequently associated with its development are abstraction, decomposition, pattern recognition, and algorithm design, whose integration supports the organization of thinking and the development of solutions to problems across different fields of knowledge.

The findings of the mapping study revealed important connections between Algebraic Thinking and Computational Thinking. In particular, both were found to share cognitive processes related to abstraction, pattern recognition, and generalization, all of which support problem formulation and problem-solving. The studies analyzed also indicate that the development of Computational Thinking can contribute to a better understanding of algebraic concepts and, conversely, that the development of Algebraic Thinking supports the construction of computational skills, demonstrating a complementary relationship between these two modes of thinking. Furthermore, most of the studies emphasize the importance of integrating plugged and unplugged activities, particularly through the use of block-based programming languages, as a strategy for fostering the development of Computational Thinking in Basic Education.

On the other hand, the mapping revealed a scarcity of studies that explicitly discuss the distinctions between Algebraic Thinking and Computational Thinking, highlighting a gap in the existing body of research. It was also observed that the studies analyzed predominantly employed natural language, algebraic language, and programming languages as forms of representation, without exploring the representation of algorithms through flowcharts. Considering that the Brazilian National Common Curricular Base (BNCC) (Brasil, 2018) recommends the study of flowchart-based algorithm representations in Mathematics classes, this finding underscores the need for further research investigating instructional strategies aimed at constructing and representing algorithms, thereby contributing to the implementation of curricular guidelines and strengthening the integration between Algebraic Thinking and Computational Thinking.

PENSAMENTOS COMPUTACIONAL E ALGÉBRICO: UMA ANÁLISE DE PESQUISAS BRASILEIRAS

RESUMO

O desenvolvimento dos pensamentos computacional e algébrico constitui um dos objetivos previstos pela Base Nacional Comum Curricular (BNCC) para a disciplina de Matemática na Educação Básica, uma vez que ambos contribuem para a formulação e a resolução de problemas em diferentes áreas do conhecimento. Nesse contexto, torna-se importante identificar os conceitos que caracterizam os pensamentos algébrico e computacional, bem como suas aproximações e formas de desenvolvimento, a partir de pesquisas brasileiras. Este trabalho originou-se de uma pesquisa bibliográfica, desenvolvida sob os pressupostos de uma abordagem qualitativa. Inicialmente, foram identificadas 16 pesquisas por meio das palavras-chave "álgebra" e "pensamento computacional". Após a leitura dos resumos, foram estabelecidos os critérios de exclusão, resultando em um corpus composto por dez trabalhos, sendo sete dissertações e três teses. A análise do material evidenciou que os autores recorreram a diferentes referenciais teóricos, organizações e documentos curriculares para identificar os conceitos que caracterizam esses pensamentos, bem como as formas de desenvolvê-los. Em relação ao pensamento algébrico, a maioria das pesquisas destaca a generalização e o estudo de padrões como elementos essenciais para o seu desenvolvimento. Quanto ao pensamento computacional, predomina a compreensão de que ele corresponde aos processos mentais envolvidos na formulação e na resolução de problemas, podendo ser explorado com ou sem o uso de computadores. Além disso, os estudos apontam a abstração, a identificação de padrões e a generalização como conceitos comuns a ambos os pensamentos. As ações propostas contemplam atividades desplugadas e plugadas, desenvolvidas em diferentes níveis de ensino, com ênfase no uso de linguagens de programação em blocos. Entretanto, as pesquisas sobre essa temática ainda são escassas, evidenciando a necessidade de novos estudos que aprofundem as aproximações e os distanciamentos entre esses pensamentos, bem como proponham atividades passíveis a serem exploradas, especialmente nas aulas de Matemática da Educação Básica.

PALAVRAS-CHAVE: Mapeamento. Padrões. Conceitos do Pensamento Computacional. Atividades desplugadas. Atividades plugadas.

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