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Computational Thinking Situations in Mathematics classes: an analysis of Elementary School textbook collections

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Abstract: This study aims to analyze how textbook collections, approved by the Programa Nacional do Livro Didático, address the algorithms construction for solving geometric problems. This is a qualitative research, based on assumptions of Content Analysis. The analysis was based on situations related to Computational Thinking and geometric concepts, contained in eight collections of Elementary School textbooks, showing skills of the Base Nacional Comum Curricular. We found that of the skills associated with Computational Thinking, EF06MA23 contained the largest number of situations involving algorithms construction. As for the representations proposed for the organization of the algorithm, approximately 46% of the mobilizations carried out were approached by exploring natural language and 41% in the flowchart/schema representation. Furthermore, only 9 situations explore different types of representation in the algorithm construction. The algorithm represented in programming language was identified in only two collections, which suggest the use of visual programming environments/*software*.

Keywords: Computational Thinking. Algorithm. Geometric Concepts. Base Nacional Comum Curricular. Textbooks.

Situaciones que involucran Pensamiento Computacional en clases de Matemática: un análisis de las colecciones de libros didácticos de la Escuela Primaria

Resumen: Este estudio pretende analizar cómo las colecciones de libros de texto, aprobados por el PNLD, abordan la construcción de algoritmos para la solución de problemas geométricos. Se trata de una investigación cualitativa, anclada en el Análisis de Contenido. El análisis se basó en situaciones relacionadas con el PC y conceptos geométricos, contenidos en ocho colecciones de libros de texto de la Escuela Primaria. Se encontró que, de las habilidades asociadas al PC, EF06MA23 contenía la mayor cantidad de situaciones que involucran la construcción de algoritmos. En cuanto a las representaciones propuestas para la organización del algoritmo, aproximadamente el 46% de las movilizaciones realizadas se abordaron explorando el lenguaje natural y el 41% en la representación de diagrama de flujo/esquema. Además, solo 9 situaciones exploran diferentes tipos de representación en la construcción del algoritmo. El algoritmo representado en lenguaje de programación fue identificado en sólo dos colecciones.

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Palabras clave: Pensamiento Computacional. Algoritmo. Conceptos Geométricos. Base Nacional Comum Curricular. Libros Didácticos.

Situações envolvendo Pensamento Computacional nas aulas de Matemática: uma análise de coleções de livros didáticos do Ensino Fundamental

Resumo: Este estudo objetiva analisar como coleções de livros didáticos, aprovadas pelo Programa Nacional do Livro Didático, abordam a construção de algoritmos para resolução de problemas geométricos. Trata-se de uma pesquisa de cunho qualitativo, ancorada em pressupostos da Análise de Conteúdo. A análise foi baseada em situações relacionadas ao Pensamento Computacional e conceitos geométricos, contidas em oito coleções de livros didáticos do Ensino Fundamental, evidenciando habilidades da Base Nacional Comum Curricular. Constatou-se que, das habilidades associadas ao Pensamento Computacional, a EF06MA23 continha o maior número de situações envolvendo construção de algoritmos. Quanto às representações propostas para organização do algoritmo, aproximadamente, 46% das mobilizações realizadas foram abordadas explorando a linguagem natural e 41% na representação de fluxograma/esquema. Além disso, somente 9 situações exploram diferentes tipos de representação na construção do algoritmo. O algoritmo representado em linguagem de programação foi identificado em apenas duas coleções, que sugerem uso de ambientes/softwares de programação visual.

Palavras-chave: Pensamento Computacional. Algoritmo. Conceitos Geométricos. Base Nacional Comum Curricular. Livros Didáticos.

1 Introduction

One of the challenges of the teaching profession is to implement recommendations from educational reforms, for example, the *Base Nacional Comum Curricular* — BNCC (BRASIL, 2018). This document proposes the development of competencies and skills, and, for the Mathematics area, their organization in a spiral curriculum perspective, emphasizing problem solving, research, project development, and modeling as methodological perspectives, which "are potentially rich in the development of fundamental competencies for mathematical literacy (reasoning, representation, communication, and argumentation) and the development of computational thinking" (BRASIL, 2018, p. 266).

One can notice that the BNCC, when mentioning the methodological perspectives for mathematical literacy, also refers to the development of Computational Thinking (CT). Concepts related to CT — for example, the construction of algorithms and their representations (natural language, flowcharts) — are mentioned in objects of knowledge and skills in Mathematics. It is noteworthy that those concepts exist in other areas of knowledge; however, most times the CT is mentioned, it is related to the Mathematics area.

In addition to the CT, the BNCC indicates the importance of working with the *digital world* and *digital culture* dimensions, distinguishing between them to “avoid reducing the role of digital technologies to the domain of very specific skills, such as learning to use specific *software* or a programming language” (REIS; BARICHELLO, and MATHIAS, 2021, p. 43). From this perspective, the intention is that students understand, use, and create digital technologies in a critical, meaningful, and ethical way for communication, access, and production of information and knowledge, problem solving, assuming leadership and authorship.

Digital technologies are present in people's daily lives. Recently, due to the Covid-19 pandemic, its use has intensified, especially in the teaching and learning process. In this situation, the students must not be only “consumers,” but protagonists of technologies, because computer use and the search for understanding how it works can offer them the possibility to think, reflect, and implement their ideas (PAPERT, 1986 *apud* MARTINS and TEIXEIRA, 2015). In addition, digital technologies are didactic resources of great impact and can be used “to structure problems and find solutions [...] using the fundamentals of Computation (Computational Thinking)” (BRACKMANN, 2017, p. 20).

In this sense, we cannot deny that the impact of these technologies requires a redirection of teaching in areas such as Mathematics, mainly in the field of Geometry. The constant search for resources for the teaching of Geometry occurs because it is “[...] a fruitful field for the development of the ability to abstract, generalize, project, transcend what is immediately sensitive” (PAVANELLO, 2004, p. 4). However, “Geometry is still an area whose treatment and approaches remain insufficient in Basic Education. When done, it is often restricted to formulas and procedures disconnected from other areas of Mathematics, from other fields of knowledge” (SBEM, 2013, p. 12).

Given the complexity of Geometry teaching and learning and the skills developed, especially when digital technologies (Dynamic Geometry software, visual programming environments) are used, initiatives to relate the CT to the mathematical skills and contents/concepts (in particular, geometric ones) have been mentioned in the literature (SASSI; MACIEL, and PEREIRA, 2021).

Although the idea of teaching concepts from different areas that contribute to the development of the CT has been discussed for decades, and some countries have already implemented in their curricula subjects focused on Computing, in Brazil, this

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

idea received greater prominence in areas such as Mathematics, with the publication of the *Base Nacional Comum Curricular* (BNCC). However, “most teachers are unaware of the theme and, consequently, have difficulties in recognizing the importance of using the CT” (JÚNIOR and OLIVEIRA, 2019, p. 62). A possible interpretation of this fact may be related to the absence of the theme in the textbook, one of the main resources adopted by teachers to prepare their plans.

For Sacristán and Pérez-Gómez (1998), the curriculum is a process with different phases: prescribed curriculum, indications presented in official documents; planned curriculum, designed to be "consumed" by teachers and students and materialized in textbooks, teachers' handbooks, etc.; organized curriculum, the proposals organized by school institutions; curriculum in action, which is the teacher planning; and the assessed curriculum, the internal and external evaluations. Considering the textbook as one of the materials that express the curriculum, it must be evaluated periodically both by the *Programa Nacional do Livro Didático* (PNLD) and by research.

Given this context, this work aims to analyze how textbook collections, approved by the *Programa Nacional do Livro Didático* — PNLD/2020, address the construction of algorithms to solve geometric problems. Therefore, the text is organized in a section that presents some ideas about the relationships between Computational Thinking and Mathematics, followed by a section that describes the methodological path taken, the analyses performed from the data obtained, and the final discussions.

2 Computational and Mathematical Thinking: some relationships

Technological advances have brought about changes in all spheres of society, requiring professionals from different areas to develop new competencies and skills to solve different problems and create technologies, especially digital ones.

When the BNCC mentions computing and digital technologies, it evidences not only their use but also their creation, as can be seen in General Competence 5:

> Understand, use, and **create digital information and communication technologies** in a critical, meaningful, reflective, and ethical way in the various social practices (including school ones) to communicate, access, and disseminate information, produce knowledge, solve problems, and champion and take the authorship in personal and collective life (BRASIL, 2018, p. 9, emphasis added).

With the emphasis given by the BNCC to computing and digital technologies, the insertion of knowledge related to this area in Basic Education has gained prominence, mainly the CT. However, in other countries, these discussions are not recent, having been first proposed in the 1960s, with Seymour Papert's Philosophy LOGO. Since then, more and more experiences have been carried out in Basic Education (MORAIS, BASSO and FAGUNDES, 2017).

In the early 2000s, the expression "Computational Thinking" was popularized by Wing (2006). For her, Computational Thinking (CT) involves solving problems, designing systems, and understanding human behavior using the fundamental concepts of Computing. In 2014, the researcher reorganized her definition as "thought processes involved in the formulation of a problem and that express their solution or solutions effectively, in such a way that a machine or a person can perform it" (WING, 2014, p. 1), adding that the CT involves the "automation of abstraction" and the "act of thinking like a computer scientist."

Rocha, Basso, and Notare (2020, p. 582) highlight that the most current definition given by Wing reveals that

> mental processes involved during problem posing and solving and how to express them can be done among humans-humans and/or humans-machine, emphasizing that this thinking is not limited to a programming language but a form of linguistic communication (visual, natural, and programming language...) that is understood and in a format accessible to the intended audience.

For the BNCC (BRASIL, 2018, p. 474), the CT involves the "capacities to understand, analyze, define, model, solve, compare, and automate problems and their solutions, methodically and systematically, through the development of algorithms." It seems that these understandings relate the CT to the mental processes involved in problems posing and solving and how to communicate, especially through algorithms.

Given the above, we used the ideas of Liukas (2019), as she presents concepts related to the development of the CT (Chart 1), which are connected with the concepts of Mathematical Thinking (MT).

Chart 1: Concepts related to Computational Thinking

Decomposition	**Process by which problems are divided into smaller fragments**
Pattern identification (Generalization)	Find similarities and patterns to solve complex problems more efficiently.
Abstraction	Process of eliminating irrelevant details to focus on the things that

	really matter.
Algorithm	Set of specific steps to solve a problem. In programming, algorithms are used to create reusable solutions to problems.

Source: Liukas (2019, p. 110-111).

From this perspective, the process of solving a problem, in general, involves identifying important characteristics and elements (abstraction); analyzing the possibility of dividing it into smaller problems (decomposition); searching for solutions or similar situations (identification of patterns) and, finally, preparing a sequential set of rules and logical steps for resolution (algorithm). In addition, it is essential to analyze whether “characteristics such as effectiveness, resource consumption, clarity, speed, ease, and other metrics that the determined solution may present are desirable” (MORETTI, 2019, p. 26). Finally, verifying whether the strategies adopted were adequate is an important action so that “small errors do not become major complications and more difficult to treat later” (MORETTI, 2019, p. 26).

When seeking understandings of the CT, one can notice some connections with issues related to the development of the MT. For example, the analysis of the understandings of different researchers of the CT (WING, 2014; ROCHA, BASSO, and NOTARE, 2020; BRACKMANN, 2017) indicates that the focus is on problem solving, whose fundamental pillar is abstraction. In other words, to solve a problem, one needs to create an abstract model that can be understood, analyzed, and described in an accurate language. Mathematics can be this language due to its universality and formalization, contributing to elaborating different models and providing several techniques to analyze them well.

For this reason, mathematics is used in several areas of knowledge, in particular, computing. This resorts to mathematics for the construction of computational models and processes, i.e., for the construction of algorithms, but “provides techniques and abstractions to assist in the process of construction and analysis of solutions, as well as languages to describe algorithms” (VICARI, MOREIRA, and MENEZES, 2018, p. 16) different from those provided by other areas.

The concepts presented in Chart 1 indicate other approximations of the CT with the MT, as it is expected that in mathematics classes based on problem solving, situations that require decomposition, identification of patterns, and abstraction will be worked on. In this perspective, the approximations between these types of thinking could be expanded if the algorithms were placed as objects of study in mathematics classes (BRASIL, 2018; REIS, BARICHELLO, and MATHIAS, 2021). In other words, the teacher should select/formulate problems whose construction of the algorithm in its different representations (natural language, symbolic, flowchart, programming language) is the final objective and not situations in which the algorithm used in the resolution is already given.

Barbosa and Maltempi (2021) signal the importance of building algorithms in natural language before conversion to other representations (flowchart, programming language). For the researchers, this construction allows describing the reasoning elaborated to solve the problem, dividing it into parts (decomposition), identifying what is most relevant (abstraction) and the regularities present (pattern recognition), correcting the steps (debugging), producing a logical sequence (algorithm).

In this context, it becomes increasingly important for the Mathematics teacher to understand the movements toward and away between the MT and the CT because, according to the BNCC (BRASIL, 2018), he/she will have to propose activities that enhance the development of competencies and skills related to the two types of thinking.

3 Methodological path

The investigation[5] that gave origin to this work aimed to analyze relationships between Computational and Mathematical thinking presented in Brazilian research that used the Scratch[6] programming environment to work on geometric concepts. Therefore, aspects such as resources and/or tools used, contents/concepts explored, and types of activities developed on the highlighted theme were some of the items analyzed. Some collections of Elementary School textbooks were also analyzed to verify the movements mentioned above with the mapped research.

Thus, this study aims to broaden and deepen the discussions of the results obtained on the situations related to the CT identified in said collections. We chose a qualitative approach because, according to Borba (2004, p. 2), this favors "descriptive procedures to the extent that its view of knowledge explicitly admits subjective interference, knowledge as an understanding that is always contingent, negotiated,

[5] OLIVEIRA, C. D. S. *Scratch no ensino e aprendizagem de Geometria: um panorama de pesquisas brasileiras*. [Scratch in the teaching and learning of geometry: a panorama of Brazilian research.] Thesis (Professional Master's Degree in Mathematics in National Network. Federal University of Pampa. Caçapava do Sul-RS. 2021.
[6] This programming environment is available at: https://scratch.mit.edu

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

and not rigidly truth".

Regarding the procedures, the data were analyzed based on assumptions of the Content Analysis. For Bardin (2011, p. 48), Content Analysis is "a set of communication analysis techniques" aiming to obtain indicators that enable the "inference of knowledge related to the conditions of production/reception" of messages.

This method is organized into three stages: pre-analysis, exploration of the material, and treatment of results and interpretations. The first, pre-analysis, consists of the organization of the research. This includes the definition of objectives, selection of documents to be analyzed, "floating" reading, and formulation of criteria and/or categories of analysis. To select the documents, we started by reading the PNLD/2020 Textbook Guide. Then, among those approved, we sought those which had a digital version available on the publisher's website and which allowed the electronic search for words/expressions. All collections were digitally available, but only eight allowed electronic searches, which were used as the research corpus.

In the collections, the representations used for analysis and/or construction of algorithms and the geometric concepts used were verified. For this, we defined some descriptors that emphasize those aspects: "*algoritmo*," "*fluxograma*," "*passo a passo*," and "*esquema*" [algorithm, flowchart, step-by-step, and scheme, respectively] and also by the code of the skills of the thematic unit Geometry, highlighted by BNCC — Mathematics, related to CT. It should be noted that these skills explicitly bring in their text the construction of algorithms. Such skills are presented in Chart 2.

Chart 2: Skills of the thematic unit Geometry, highlighted by BNCC-Mathematics related to CT

Year	Skill	Description
6th	EF06MA23	Build an algorithm to solve step-by-step situations (such as in the construction of folds or the indication of displacement of an object in the plane according to reference points and distances provided, etc.).
7th	EF07MA26	Describe, in writing and through a flowchart, an algorithm for the construction of any triangle, given the measurements of the three sides
	EF07MA28	Describe, in writing and through a flowchart, an algorithm for the construction of a regular polygon (such as a square and equilateral triangle), given the measurement on its side.
8th	EF08MA16	Describe, in writing and through a flowchart, an algorithm for the construction of a regular hexagon of any area, from the measurement of the central angle and the use of set-squares and a compass.
9th	EF09MA15	Describe, in writing and through a flowchart, an algorithm for the construction of a regular polygon whose side measurement is known, using a ruler, a compass, and software.

Source: Brasil (2018).

The second stage, exploration of the material, corresponds to data analysis and production. In this stage, we sought to investigate in the textbook collections the descriptors listed, searching for situations that contribute to developing CT in the student. We analyzed eight collections, identifying them with codes as follows: *A Conquista da Matemática* (C1); *Araribá Mais* (C2); *Matemática - Bianchini* (C3); *Matemática - Compreensão e Prática* (C4); *Matemática Essencial* (C5); *Matemática Realidade & Tecnologia* (C6); *Teláris Matemática* (C7); *Trilhas da Matemática* (C8).

For each situation[7] identified, the following information was collected: collection; year of education; content/concept; skill; and representation used to construct of the algorithm. From the information, in the stage of treatment of the results and interpretations, we organized charts to contribute to reading and understanding the data obtained.

4 Algorithms in situations involving geometric concepts: analysis of textbook collections

From the descriptors, we identified 66 situations, 21 of which were not classified in Chart 3, as they are not directly related to the skills mentioned in Chart 2. Thus, 45 situations were analyzed and classified in Chart 3, according to the skill contained in the BNCC – Mathematics, and representation mobilized in the construction of the algorithm. It should be noted that the representations of the algorithms were classified into natural language (NL); flowchart/scheme[8] (F/S); programming language (PL), and symbolic (S).

Chart 3: Organized situations regarding the skills of the BNCC – Mathematics, and representation mobilized in the construction of the algorithm

Skill	Rep.	Collections							
		C1	C2	C3	C4	C5	C6	C7	C8
EF06MA23	NL	S01[9]	-	S03	-	S04	-	S08 S09 S11	S12 S13 S14 S15
	F/S	-	-	-	-	-	-	-	-
	PL	-	-	-	-	-	-	-	-
	S	-	S02	-	-	S05	S06 S07	S10	-

[7]The term “situation” refers to explanations of the contents/concepts, examples, and activities covered in textbooks.
[8]This format was chosen because not all algorithms represented visually can be considered flowcharts (since they do not use the recommended symbology — ISO 5807-1985).
[9]SXX, indicates S: Situation; XX: activities in sequential counting by collection.

EF07MA26	NL	-	-	-	-	-	-	S17	-
	F/S	-	-	-	-	S16	-	-	S18
	PL	-	-	-	-	-	-	-	-
	S	-	-	-	-	-	-	-	-
EF07MA28	NL	-	-	-	S22	S24	S25	S26	-
	F/S	S19	S20	S21	-	S23 S24	S25	-	-
	PL	-	S20	-	-	-	-	-	-
	S	-	-	-	-	-	-	-	-
EF08MA16	NL	-	S27	S28	S29	-	S31	S32	-
	F/S	-	S27	-	S29	S30	S31	-	S33
	PL	-	-	-	-	-	-	-	-
	S	-	-	-	-	-	-	-	-
EF09MA15	NL	-	-	-	-	S39	S41	S43 S44	S45
	F/S	S34	S35	S36	S37	S39 S40	S41 S42	-	S45
	PL	-	-	-	S38	-	-	-	-
	S	-	-	-	-	-	-	-	-

Source: Organized by the authors.

The number of situations in each collection ranges from three (case of C1) to nine (case of C7). This result reveals that not all collections (C1, C2, C3, C4, C6, C8) present situations for the five selected skills. Of the 45 situations classified, 20 are activities, that is, situations that ask the student to build an algorithm to solve the given geometric problem, especially C5, which has eight of the 20 activities. In other situations, the algorithm (natural language, flowchart) is already given, so the student, in general, only needs to follow the steps to build a geometric figure, which limits the mobilization of CT concepts (LIUKAS, 2019; BARBOSA e MALTEMPI, 2021; BRASIL, 2018).

In Chart 3, we see that nine situations (S20, S24, S25, S27, S29, S31, S39, S41, S45) are repeated because they explore different types of representation in the construction of the algorithm. Eight of the nine situations above explore the algorithm in the representation in natural language and through a flowchart (Figure 1), and one of those eight works with the representation in a programming language. In addition, three of the eight situations identified are in C6. The fact that 36 of the 45 activities present only one representation contradicts the indications of BNCC - Mathematics, since four of the five skills (Chart 2) mention that the algorithm must be presented in

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

writing (NL) and through a flowchart (F).

Figure 1: Example of situation (S29) involving algorithm represented in natural language and through flowchart

Observe as frases abaixo. Se as colocarmos na sequência correta, obteremos o passo a passo para construir um hexágono regular.

A • Construa um ângulo central de 60º.

B • Construa um ângulo central adjacente ao anterior.

C • Trace um segmento de reta consecutivo ao anterior, fechando o polígono.

D • Trace um segmento de reta unindo os pontos obtidos.

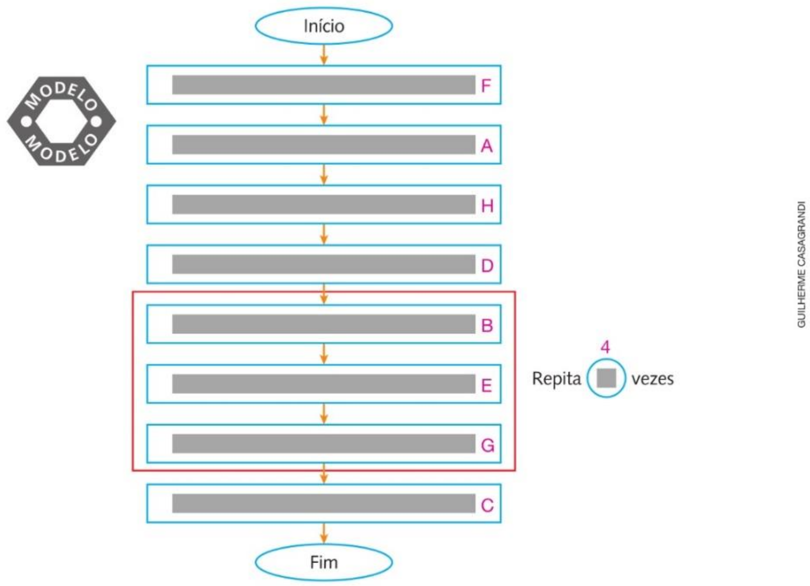
E • Marque a intersecção do último lado do ângulo construído com a circunferência.

F • Construa uma circunferência.

G • Trace o segmento de reta consecutivo ao anterior, unindo-o ao último ponto obtido.

H • Marque a intersecção dos lados do ângulo com a circunferência.

a) Reproduza o esquema abaixo em seu caderno e complete-o com a sequência correta das instruções. Note que, no esquema, há um grupo de passos que devem ser repetidos para obtermos o hexágono regular. Indique, no campo adequado, a quantidade de vezes que esse grupo deve ser repetido. Identificando as instruções por letras, temos que a sequência correta é:



b) Utilizando a ideia acima como referência, elabore, no caderno, um esquema com uma sequência de comandos para a construção de outro polígono regular. Resposta pessoal.

c) Troque de caderno com um colega e tente construir o polígono conforme orientação no esquema. Resposta pessoal.

d) Discuta com o colega os esquemas elaborados, analisando se as instruções produziram o polígono desejado. Caso isso não tenha ocorrido, investiguem se houve falha no comando ou na sequência dos comandos inseridos no esquema. Resposta pessoal.

Source: Excerpt from C4 (p. 111).

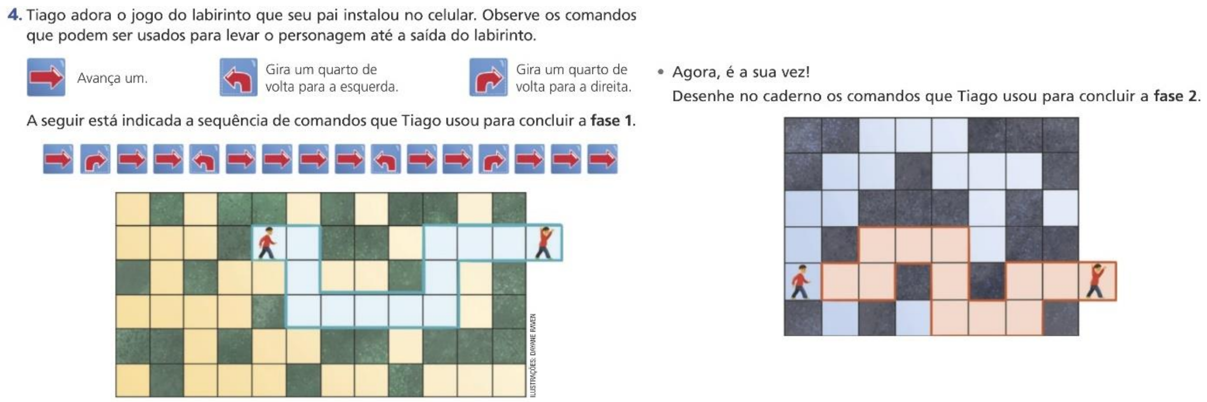
The situation presented in Figure 1 explores in an articulated way two representations of an algorithm, natural language, and flowchart/scheme. Steps (algorithm in natural language) that must be organized in a logical sequence are taken to obtain a regular hexagon. For this, it is necessary to analyze the essential elements (abstraction) and identify similarities and regularities (identify patterns). Then, a flowchart (algorithm) must be built. It is noteworthy that the symbology used in the

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

flowchart[10] is close to the recommended one, except for the form adopted to represent the four repetitions[11]. We understand that in the activities proposed for Elementary School involving flowcharts, the representations of three functions must be standardized: Termination — to indicate the beginning and the end of the algorithm, an oval-shaped symbol is used; Process/Action — the processes/actions/functions are represented by rectangles; and Decision — decision making must be represented by rhombuses.

The skill related to CT indicated for the 6th grade is EF06MA23, which was identified in 15 situations distributed in seven collections. The analyzed situations, in general, explore the algorithm only in the representation in natural language (NL), ten situations, and in the symbolic representation (S), five situations. C7 and C8 stand out for presenting four situations each, with emphasis on natural language (only one situation of C7 is in symbolic representation). The geometric concepts addressed in the situations involve: displacement and location (S01, S03, S04, and S06 – Figure 2); construction of parallel and perpendicular lines (S05, S07, S08, S09, S10, S13); and construction of plane figures (S02, S11, S12, S14, S15).

Figure 2: Situation S06 involving symbolic language when exploring displacement and location



Source: Excerpt from C6 (p. 85).

The situation shown in Figure 2 requires that, to move the character in the maze and solve the given problem, the player identifies the relevant information (abstraction) and the pattern presented in the maze (generalization) to elaborate a set of steps (algorithm), using the symbols available in the game. We perceive that, intuitively, the concept of angle (understood as a gyre) is being explored when the player needs to decide whether the gyre will be clockwise or counterclockwise. We understand that

[10]According to Standard ISO 5807-1985.

[11]According to ISO 5807-1985, repetitions can be indicated by decision making from counting a variable or by repetition from a control variable.

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

using symbols to build algorithms, especially at the beginning of the work, contributes to appropriating computational and mathematical concepts. It is important to note that the other situations related to this ability potentiate the mobilization of CT concepts, such as abstraction and identification of patterns, fundamental to the construction of the algorithm.

The 7th grade has two CT-related skills: EF07MA26 and EF07MA28. Regarding EF07MA26, only three situations were identified, each in a different collection (C5, C7, C8). Two of them approach the representation of the algorithm through flowchart/scheme (S16, S18) and one in natural language (S17). The situations classified in this skill address the construction of any triangle, given the measurements of its sides, emphasizing the use of drawing instruments, such as a ruler, compass, and protractor. In S18 (Figure 3), besides the steps for the construction of the triangle, in the flowchart, the condition of existence is evidenced.

We observe that this situation makes it possible to mobilize the algorithm and the following CT concepts: abstraction, pattern identification, and decomposition. The latter is because it is possible to separate the problem into two parts: one of the verification that the measurement of the sides of the triangle meets the condition of existence and another that, once the first is verified, indicates the steps for the construction of the triangle. We emphasize that working with decision-making is important not only for solving mathematical problems but also for computational ones. It is also relevant to point out that the flowchart presented in Figure 3 follows the construction recommendations present in Standard ISO 5807-1985.

Regarding the skill EF07MA28, eight situations were identified, distributed in seven collections, and classified in natural language, flowchart/scheme, and programming language. Three of those situations mobilize two types of representation; however, only S24 requests two distinct representations to solve the same activity. Particularly, this situation in C5 brings the algorithm in natural language for constructing a regular pentagon. Then, it asks the student to describe, in written form (natural language) and through a flowchart, the procedures used to build a square with a side of 4 cm.

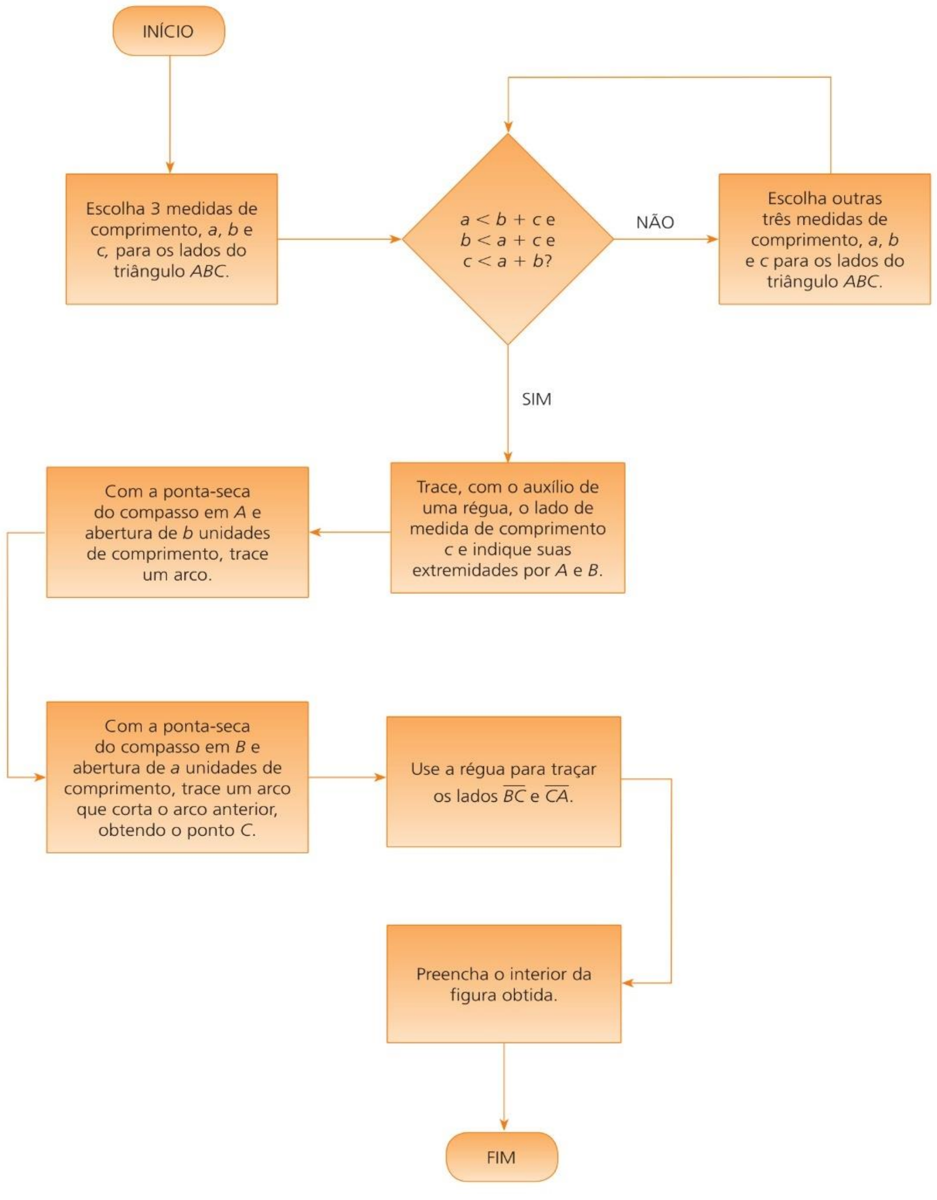
REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

Figure 3: Excerpt from situation S18 involving an algorithm represented in a flowchart/scheme that addresses the condition of existence of a triangle

Fluxograma

Acompanhe a situação a seguir.

O professor de Matemática do 7º ano elaborou um fluxograma que apresenta um processo a ser seguido pelos alunos para construírem um triângulo com base nas medidas de comprimento de seus lados.

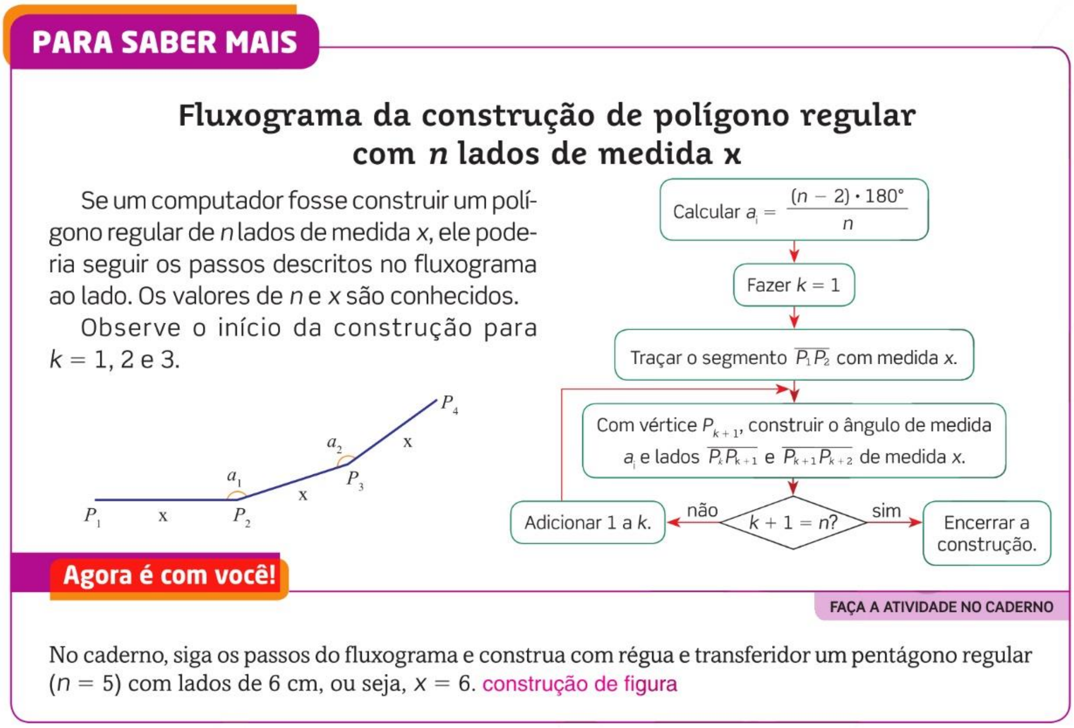


Source: Excerpt from C8 (p. 174).

In situations related to EF07MA28, the equilateral triangle constructions (S19, S20, S22, S23, S26), square (S20, S24, S25, S26) and pentagon (S24) were explored. Regarding the concepts of CT, we can say that abstraction and pattern identification are evidenced, in addition to the algorithm. Still, one of them – S21 (Figure 4) – addresses the steps for constructing a regular polygon that has n sides, with emphasis on a programming language, organized through a flowchart.

Furthermore, this is the only activity that proposes elaborating an algorithm for constructing a regular polygon of n sides. The proposition of this type of activity is important to verify whether students can abstract and identify patterns, which allows for the generalization of essential capacities for the development of CT and MT (BARBOSA and MALTEMPI, 2021; BRASIL, 2018).

Figure 4: Situation S21 involving algorithm represented in Flowchart/Scheme with emphasis on a programming language

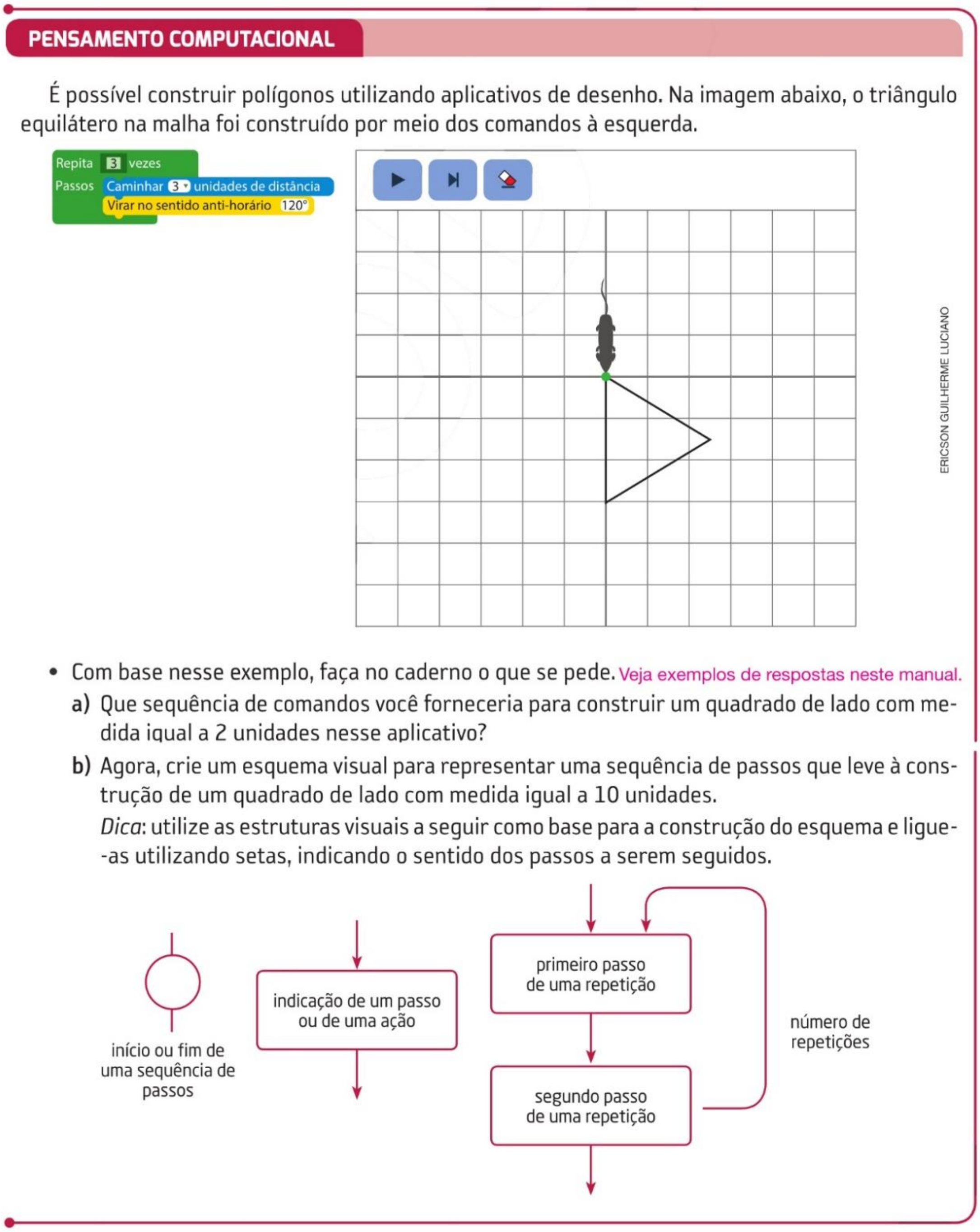


Source: Excerpt from C3 (p. 237).

Also, regarding the EF07MA28 skill, C2 classifies the only situation S20 (Figure 5) that involves an algorithm represented in a programming language, indicating the use of a visual programming language (in the authors' words, drawing application). This particular collection has sections (titled “Box”) on Computational Thinking. We notice that the proposed situations, in general, refer to the mapped skills (Chart 2), bringing the construction of the algorithm — in its different representations — to the center of the discussions, unlike the other collections that, for the two skills of the 7th grade, emphasize the description of steps for the construction of geometric figures from drawing instruments or tools of a Dynamic Mathematics software (for example, GeoGebra).

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022
Revista de Ensino de Ciências e Matemática

Figure 5: Excerpt from situation S20 involving an algorithm represented in a visual programming language



Source: Excerpt from C2 (p. 228).

The 8th grade has a CT-related skill (EF08MA16) that refers to the organization of an algorithm for building a specific regular polygon, the hexagon, given the measure of its central angle, using construction tools (square and compass), describing the steps through the representations of natural language and flowchart. Seven situations were identified, one in each collection (only C1 did not explore). These were classified in the representations: natural language (S28 — Figure 6, S32), flowchart/scheme (S30, S33), and, in particular, three situations request both representations for the

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

resolution of the activity (S27, S29, S31).

As for the concepts of the CT, besides the algorithm, the situations require the mobilization of abstraction and identification of patterns.

Figure 6: Excerpt from situation S28 involving algorithm represented in natural language

A partir dessa experiência, Márcia e Mílton verificaram que é possível construir hexágonos regulares traçando arcos ou ângulos centrais de 60° e apresentaram um trabalho escolar descrevendo um algoritmo com os passos a seguir.

Márcia

- Traçar uma circunferência de centro *O* e raio *r*.
- Traçar uma semirreta qualquer de origem *O*, que corta a circunferência no ponto *A*.
- Com a ponta-seca do compasso em *A* e abertura igual ao raio, traçar um arco obtendo *B* e *F* na circunferência.
- Repetir o traçado do arco com centros em *B*, *C* e *D*, obtendo na circunferência, respectivamente, *C*, *D* e *E*.
- Traçar $\overline{AB}$, $\overline{BC}$, $\overline{CD}$, $\overline{DE}$, $\overline{EF}$ e $\overline{FA}$.

Mílton

- Traçar uma circunferência de centro *O* e raio *r*.
- Encostar em *O* a ponta (vértice do ângulo de 60°) do esquadro e traçar um ângulo de 60° que corta a circunferência nos pontos *A* e *F*.
- Ainda com a ponta do esquadro em *O*, traçar ângulos de 60° adjacentes a $A\widehat{O}F$, obtendo *B* e *E*.
- Repetir o passo anterior, traçando ângulos de 60° adjacentes a $A\widehat{O}B$ e $F\widehat{O}E$, obtendo *C* e *D*.
- Traçar $\overline{AB}$, $\overline{BC}$, $\overline{CD}$, $\overline{DE}$, $\overline{EF}$ e $\overline{FA}$.

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FAÇA AS ATIVIDADES NO CADERNO

1 Construa dois hexágonos regulares com lados de 4 cm, um pelo algoritmo de Márcia e o outro pelo de Mílton. construção de figura

2 Em uma circunferência de raio 4 cm, construa um dodecágono regular traçando ângulos centrais de 30° com um esquadro. construção de figura

Source: Excerpt from C3 (p. 172).

This situation (Figure 6) allows the student to analyze different constructions of the algorithm and evaluate their differences. In addition, the situation could be expanded, for example, by requesting the elaboration of the flowcharts that represent each of the data algorithms in natural language.

Working with algorithms in different representations enhances the process of thinking about thinking (BARBOSA and MALTEMPI, 2021), since the version built on a representation must be reviewed, rethought, and improved for conversion into another because this action requires identifying the pertinent aspects/variables of each representation and the implication of one on the other.

Finally, in the 9th, 6th, and 8th grades, there is only one skill related to CT

(EF09MA15), and 12 situations were identified in the eight collections analyzed. These were classified, according to their representations, in natural language (S43, S44), flowchart/scheme (S34, S35, S36, S37, S40, S42), and programming language (S38). Still, three (S39, S41, S45) mobilize two representations (natural language and flowchart/scheme) in a situation, and one proposes the development of both in the same solution. This case, in particular, refers to constructing a square and a dodecagon, given the measure on its side (S39).

The situations identified in this skill involve the structures of equilateral triangle (S41, S43), square (S42, S43), pentagon (S34, S40, S43), hexagon (S39, S41, S44, S45), octagon (S35, S38 — Figure 8) and dodecagon (S39). Some other situations (S34, S36, S37) that mention the construction of a regular polygon of n sides were also verified, organized from flowcharts/schemes. With regard to the concepts of Computational Thinking, we can say that abstraction and identification of patterns are evidenced beyond the algorithm.

S36 (Figure 7), for example, addresses this construction through a patterned-fabric production context, in which it is necessary to program a machine for this.

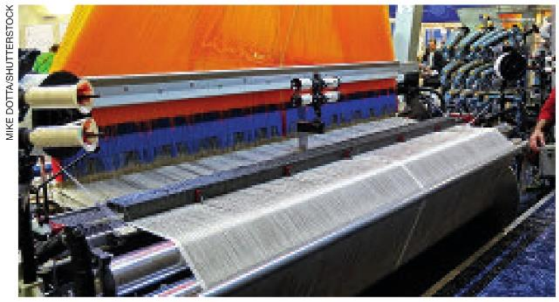
In this situation (Figure 7), the algorithm proposed in both the natural language and the flowchart shows the algebraic mathematical language, which favors the conversion to a programming language. We would like to remark that programming cannot be considered as a simple translation from one representation to another, just as it is not immediate to convert from a representation, for example, algebraic to graphic, because, in both cases, as already mentioned, the identification of the relevant variables of each representation and the implication of one in the other is required.

Figure 7: Situation S36 involving algorithm represented in Flowchart/Scheme when exploring the construction of a regular n-sided polygon

PARA SABER MAIS

Construção de polígono regular de *n* lados

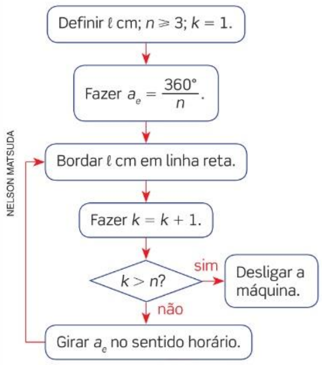
Lizandra precisa programar um tear eletrônico para compor contornos de polígonos regulares na fabricação de tecidos.



Tear eletrônico usado na indústria têxtil para a produção de tecidos com padrões criados por computador.

Veja as etapas do programa que ela elaborou para a máquina seguir, também descritas no fluxograma.

Fluxograma



1. Definir o comprimento ℓ cm do lado do polígono.
2. Definir o número *n* de lados do polígono, $n \geqslant 3$.
3. Definir o número $k = 1$.
4. Calcular a medida $a_e = \frac{360°}{n}$ do ângulo externo.
5. Bordar em linha reta caminho com ℓ cm.
6. Fazer $k = k + 1$.
7. Se $k > n$, desligar a máquina.
8. Girar no sentido horário a_e graus e voltar para o item **5**.

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FAÇA AS ATIVIDADES NO CADERNO

1 Seguindo as etapas descritas por Lizandra, escolha um número *n* de lados e construa em uma folha avulsa um polígono regular com lados medindo 6 cm. construção de figura

2 Construa novamente o polígono da atividade 1 mudando o item 8 para "Girar no sentido anti-horário a_e graus e voltar para o item **5**." construção de figura

Source: Excerpt from C3 (p. 289).

Figure 8 shows an example of a situation (S38) in which the use of a visual programming language for construction of regular polygons is suggested.

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

Figure 8: Situation S38 involving algorithm represented in visual programming language when exploring the construction of regular polygons

17 A figura abaixo mostra um bloco de comandos realizado no *Tucaprog* (*software* de programação visual disponível em: <https://www.humorcomciencia.com/apps/tucaprog/>. Acesso em: 5 out. 2018).

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Observe os comandos e responda às questões a seguir.

a) Esse bloco de comandos dá origem a qual polígono regular? octógono regular

b) Em um polígono regular temos o ângulo central, o ângulo interno e o ângulo externo. Qual deles está representado no comando "Virar no sentido horário 45°"? ângulo externo

c) Utilize o *Tucaprog* para construir um tetracoságono regular (polígono com 24 lados). Construção de figura no *software*.

Source: Excerpt from C4 (p. 255).

In the situation above (Figure 8), a block with some commands created in the TucaProg[12] programming language is presented. Therefore, some questions are asked about the type of figure that the block will build, the reference angle used for the construction, and, from the ideas present in the given code, the request to build another code for the drawing of a regular tetracosagon. The construction of the algorithm in this environment (as in Scratch) allows students to identify that the procedure involves thinking about the external angles of the polygons and that these are obtained from the division of 360º by the number of sides (generalization). This can be considered a different perspective of the construction of a regular polygon using, for example, drawing instruments or Dynamic Mathematics software.

In the BNCC of Elementary School, there are no indications for the use of programming languages. Perhaps for this reason, of the eight collections of textbooks analyzed, only two suggest the use of block programming languages (C2, C4) and most prioritize the description of the step-by-step to build geometric figures with drawing instruments or with Dynamic Geometry software.

5 Final discussion

The constant advancement of technologies — especially digital ones — requires that schools reorganize their pedagogical practices so that both teachers and students

[12]This *software* is available at the following link: https://www.humorcomciencia.com/apps/tucaprog

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

are not only consumers of those technologies but are part of the development process. Researchers and curricular proposals have problematized and defended the insertion of ideas related to computing in Basic Education, articulated with other areas of knowledge, in particular, mathematics.

Considering that the textbook generally defines what is taught and how it is taught (LAJOLO, 1996), it is essential to identify the approach proposed by these resources, which express one of the phases of the curriculum for themes such as the insertion of computer ideas in mathematics classes, since PNLD makes a general analysis of the works.

Assuming this perception, we analyzed eight Elementary School textbook collections approved by the PNLD/2020, focusing on situations involving algorithms for solving geometric problems, highlighting the five skills related to CT and the thematic unit Geometry indicated by BNCC — Mathematics.

66 situations were identified, of which 45 were classified as being directly related to the five skills. Only 20 of the 45 situations require the student to build the algorithm in at least one of its representations. This result reveals that the students' construction of the algorithm must still be better explored to meet the indication of BNCC — Mathematics that the algorithm should be studied in mathematics classes. In other words, that the mathematical concepts, in particular, the geometrical ones, can be explored in other ways to meet the provisions of the BNCC on Mathematics and its relations with the CT.

Of the skills analyzed, we verified that the EF06MA23 contained the largest number of situations (15) involving the construction of algorithms. Also, EF09MA15 was the only one with situations in all analyzed collections. As for the representations proposed for the organization of the algorithm in the situations, approximately 46% of the mobilizations were addressed by exploring the natural language and 41% through a flowchart/scheme. Only nine situations (20%) explored different types of representation in the construction of the algorithm. The algorithm represented in the programming language was identified in only two collections (C2 and C4), which suggests the use of visual programming environments/software.

We could also verify that the analyzed situations enable the mobilization of concepts related to CT, especially abstraction, pattern identification, and algorithm. Thus, we can affirm that the field of Geometry is pertinent to the development of skills essential to the promotion of CT. However, it is necessary to rethink the role of the algorithm in solving mathematical problems.

Finally, we highlight the importance and need for future research that deepens the analysis of situations also in high school textbook collections, addressing the relationships between Computational and Mathematical Thinking, as there is a natural and historical connection between CT and Mathematics.

References

BARBOSA, L. L. S. MALTEMPI, M. V. Matemática e Pensamento Computacional: possibilidades através da construção de algoritmos. **Boletim SBEM-SP**, n. 4, p. 13-15, ago. 2021.

BARDIN, L. **Análise de Conteúdo**. São Paulo: Edições 70, 2011.

BORBA, C. M. A Pesquisa Qualitativa em Educação Matemática. In: 27ª reunião anual da ANPEd, 2004, Caxambu. **Anais da 27ª reunião anual da Anped**, Caxambu, 2004.

BRACKMANN, C. P. **Desenvolvimento do pensamento computacional através de atividades desplugadas na Educação Básica**. 2017. 226f. Tese (Doutorado em Informática na Educação). Universidade Federal do Rio Grande do Sul. Porto Alegre.

BRASIL. Ministério da Educação. Secretaria de Educação Básica. **Base Nacional Comum Curricular**. Brasília: MEC/SEB, 2018.

JÚNIOR, P. A. P., OLIVEIRA, S de. Pensamento computacional: uma proposta de oficina para a formação de professores. **RENOTE**, Porto Alegre, v. 17, n. 1, p. 62-71, 2019.

LAJOLO, M. Livro didático: um (quase) manual de usuário. **Em aberto**. Brasília, v. 26, n. 69, p. 3-7, jan./mar., 1996.

LIUKAS, L. **Olá, Ruby**: uma aventura pela programação. Tradução de Stephanie C. L. Fernandes. São Paulo: Companhia das Letrinhas, 2019.

MORAIS, A. D. de, BASSO, M. V. de A., FAGUNDES, L. da C. Educação Matemática & Ciência da Computação na escola: aprender a programar fomenta a aprendizagem de matemática? **Ciência e Educação**, Bauru, v. 23, p. 455-473, 2017.

MARTINS, A. R., TEIXEIRA, A. C. Da experiência na educação para a informática educativa. **Revista Brasileira de Ensino Superior**, Passo Fundo, v. 1, n. 2, p. 34-41, out./dez, 2015.

MORETTI, V. F. **O pensamento computacional no ensino básico**: potencialidades de desenvolvimento com o uso do Scratch. 2019. 105f. Trabalho de Conclusão de Curso (Graduação em Matemática Licenciatura). Instituto de Matemática e Estatística. Universidade Federal do Rio Grande do Sul. Porto Alegre.

PAVANELLO, M. R. Por que Ensinar/aprender Geometria? In: VII ENCONTRO PAULISTA DE EDUCAÇÃO MATEMÁTICA, 2004, São Paulo. **Anais do VII EPEM**,

REnCiMa, São Paulo, v. 13 n. 6, p. 1-23, dec. 2022

São Paulo: USP, 2004.

REIS, S. R., BARICHELLO, L., MATHIAS, C. Novos conteúdos e novas habilidades para a área de Matemática e suas Tecnologias. **Revista Internacional de Pesquisa em Educação Matemática**, Brasília, v. 11, n. 1, p. 37-58, 2021.

ROCHA, K. C. da, BASSO, M. V. de A., NOTARE, M. R. Aproximações teóricas entre Pensamento Computacional e Abstração Reflexionante. **RENOTE,** Porto Alegre, v. 18, p. 581-590, 2020.

SACRISTÁN, J. G., GÓMEZ. A. I. P. **Compreender e transformar o ensino**. Porto Alegre: Artes Médicas, 1998.

SASSI, S. B., MACIEL, C., PEREIRA, V. C. Revisão sistemática de estudos sobre computação desplugada na educação básica e superior de 2014 a 2020: tendências no campo. **Contexto & Educação**, Ijuí, v. 36, n. 114, p. 10-30, maio/ago. 2021.

SOCIEDADE BRASILEIRA DE EDUCAÇÃO MATEMÁTICA-SBEM. **A formação do professor de Matemática no curso de licenciatura**: reflexões produzidas pela comissão paritária SBEM/SBM. Brasília: Sociedade Brasileira de Educação Matemática, Boletim SBEM, n. 21, fevereiro, p. 1-42, 2013.

VICARI, R. M., MOREIRA, Á., MENEZES, P. B. **Pensamento Computacional:** revisão bibliográfica. Projeto UFRGS/MEC, Universidade Federal do Rio Grande do Sul, 2018.

WING, J. M. **Computational Thinking**. Communications of the ACM, v. 49, n. 3, p.33-35, mar. 2006.

WING, J. M. Computational Thinking Benefits Society. Social Issues In: **Computing**, New York, 10 jan. 2014.