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Computational Thinking in the Context of a STEAM Project: Investigating a Socio-environmental Problem in Mathematics Classes at a Brazilian High School

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Abstract

Involving students in solving school-related problems can enhance learning across various subjects, including mathematics. Computational Thinking (CT) can be employed in this context, fostering the development of logical reasoning and problem-solving skills. Thus, this article aims to analyze the use of CT in developing a STEAM pedagogical practice where students seek solutions to the problem of pigeon proliferation on the school's sports court. A qualitative methodology was adopted, utilizing an action-research model and multimedia recordings for data collection. The participants were 32 second-year high school students (10 girls and 22 boys) from a public school in Natal, Rio Grande do Norte, Brazil. The results suggest that students employed the four pillars of CT—decomposition, pattern recognition, abstraction, and algorithms—as well as certain "6Cs" global competencies: creativity, critical thinking, and collaboration. The study concludes that it is feasible to implement pedagogical practices in mathematics that integrate CT across the curriculum alongside STEAM projects. Consequently, learning became meaningful by grounding the activity in the school's reality—specifically, a genuine socio-environmental issue. Furthermore, the use of computing within STEAM projects provided an opportunity to mobilize mathematical and computational skills outlined in the Basic Education curriculum. Furthermore, there was an opportunity to mobilize mathematical and computational skills—as outlined in K-12 curricula—through the use of computing in STEAM projects. Additionally, students' perceptions revealed increased awareness and attitudes aimed at improving collective health.

INTRODUCTION

Mathematics education in Brazil faces several challenges regarding student motivation, the lack of a connection between students lived realities and the material studied, and the persistence of teaching methods that prioritize rote rule repetition over meaningful understanding. In many schools, mathematics is still taught mechanically, with an excessive focus on conceptual content; this can hinder the development of broader competencies such as critical thinking, creativity, and problem-solving skills. According to Selbach (2015), this approach reinforces the belief that mathematics is not accessible to everyone; to counter this, it is necessary to move away from decontextualized practices and instead promote strategies that foster curiosity, student agency, and the active construction of knowledge.

In this context, Computational Thinking (CT) emerges, helping to transform how students interact with knowledge and fostering problem-solving through investigative, creative, and collaborative processes. The STEAM approach (integrating Science, Technology, Engineering, Arts, and Mathematics) also provides a vital foundation by proposing the integration of knowledge around concrete problems through inquiry and collaborative problem-solving; according to Lima and Batista (2023), this stimulates the development of the cognitive and socio-emotional competencies necessary for students' holistic development.

From this perspective, this article aims to analyze how the use of Computational Thinking in developing a STEAM-based pedagogical practice within high school mathematics classes contributed to solving a socio-environmental problem experienced at the school itself: the proliferation of pigeons on the sports court of a public school in Natal, Rio Grande do Norte. The reported experience involved 32 second-year high school students and was conducted using a qualitative approach. Throughout the text, connections are drawn to the STEAM approach, which offers students the opportunity to explore and experiment, in a practical and creative manner, with concepts and knowledge across various fields of study (Machado & Girotto-Júnior, 2019; Author et al., 2024; Maia & Soares, 2025).

In this study, the proliferation of pigeons on the school's sports court was identified as an urgent socio-environmental issue that interfered with the use of the physical space and posed health risks to the school community. Bringing this topic into mathematics classes made it possible to connect the curriculum to the local reality, sparking discussions on sustainability, citizenship, and the planning of concrete actions, while enabling the class to actively engage in seeking solutions to the problem. To analyze this context, the study sought to answer the following research question: How does Computational Thinking, combined with the STEAM approach, assist students in solving school-related problems?

The STEAM approach is grounded in Seymour Papert's Constructionism (Maia & Soares, 2025), proposing that students interact with the subject matter and create

solutions for it, such that the resulting product represents their thought process. This approach also aligns with the fundamentals of Computational Thinking, understood as a competency for solving problems in a logical, structured, and efficient manner (Wing, 2006). Through strategies such as problem decomposition, pattern recognition, information abstraction, and algorithm construction, students were able to investigate the situation, analyze collected data, and propose solutions based on mathematical reasoning. Computational Thinking can be integrated across the school curriculum, as guided by the National Common Curricular Base (BNCC[1]), particularly in subjects like mathematics, fostering the development of logical reasoning and student autonomy in solving real-world problems (Syafril et al., 2022). Indeed, as highlighted by Valente (2019), Papert himself, when discussing his concept of learning, referred to Computational Thinking as a strategy for students to reflect on their own thinking processes and to think like machines through "powerful ideas" and “procedural knowledge”.

To present this experience in a structured and comprehensible manner, this paper is organized as follows: Section 2 outlines the theoretical framework; Section 3 details the methodology, covering the nature of the research, participants, data collection instruments, the research question, and the teaching method; Section 4 presents the results and discussion, following the stages of the teaching sequence, referred to as the four pillars of CT; and Section 5 concludes the paper by summarizing the key findings of the process.

THEORETICAL FRAMEWORK

When proposing an analysis of the use of Computational Thinking (CT) in pedagogical practice, specifically where students seek solutions to the proliferation of pigeons on the school sports court, integrated with mathematics instruction and aimed at solving a real-world socio-environmental problem, it is essential, first and foremost, to understand the foundations of Computational Thinking. Since the proposal establishes connections with the STEAM approach, which values the integration of Science, Technology, Engineering, Arts, and Mathematics, a brief contextualization of this perspective is also provided.

The concept of Computational Thinking was popularized by Jeannette Wing (2006), who argued that this competency should be incorporated into the education of all citizens, not just those involved in Computer Science. For Wing, CT involves a specific way of formulating problems and organizing solutions by drawing on computing principles to address various contexts, extending far beyond the mere act of programming or using digital tools. She maintains that thinking

[1] Although this document is referred to in the text by its English translation, Common National Curriculum Base, the authors have chosen to retain the original Portuguese acronym, BNCC (Base Nacional Comum Curricular), as it is the widely recognized and standard designation within Brazil.

computationally is as fundamental as reading, writing, and calculating, highlighting its importance as a skill to be developed from the early stages of basic education.

Within the Brazilian curriculum framework, CT is recognized as a set of capabilities involving the analysis, modeling, and resolution of problems in a logical, methodical, and systematic manner, utilizing computing principles such as algorithm construction and process automation (Brazil, 2018). From an academic standpoint, Brackmann (2017) expands on this idea, viewing CT as a strategic human capability linked to the critical and creative ability to apply computing theories across diverse fields of knowledge. The goal is to solve problems, whether individually or collectively, by following clear steps that others can subsequently replicate.

Brackmann (2017) points out that studies developed by organizations such as Code.org[2], BBC Learning[3] and researchers such as Liukas (2015) and Grover and Pea (2013), together with guidelines proposed by entities such as Computer Science at School, have systematized CT around four fundamental components: decomposition, pattern recognition, abstraction and algorithm. These elements are known as the "four pillars of Computational Thinking" and are widely accepted and recognized by scholars in the field.

In Brazil, Computational Thinking has been recognized as an essential skill by the National Common Curricular Base (BNCC), appearing both as a dimension linked to one of the general competencies of Basic Education (Digital Culture) and as a core axis of the BNCC Computing curriculum.

Within the Brazilian context, initiatives aimed at developing Computational Thinking only began to gain traction in scientific literature from 2015 onwards, as indicated by a systematic mapping study conducted by Ortiz and Pereira (2018). According to the authors, the volume of publications on the subject has grown significantly, placing Brazil second only to the United States between 2007 and 2017. The Brazilian initiatives identified focus predominantly on Basic Education, with relatively little exploration of the interdisciplinary nature of Computational Thinking. Examples of such initiatives include the work of Braz and Barcellos (2024), which presents studies based on experiences in public schools, demonstrating the potential of Computational Thinking as a pedagogical strategy for high school education.

The finding by Ortiz and Pereira (2018) that Brazilian Computational Thinking (CT) initiatives still only tentatively explore their interdisciplinary potential highlights a significant gap in the country's educational landscape. In this regard, the proposal presented and implemented here helps fill this void by linking CT with

[2] Website: https://code.org/.

[3] https://www.bbcstudioslearning.com/.

mathematics instruction to address a socio-environmental issue, enabling students at a state school in Natal, RN, to seek solutions through an interdisciplinary and formative approach.

This proposal is also grounded in the STEAM approach, understood as the integration of knowledge from Science, Technology, Engineering, Arts, and Mathematics into creative, inquiry-based practices centered on learning experiences that address real-world problems, particularly those arising from the students' own contexts (Maia & Soares, 2025). Custódio and Rosa (2024) emphasize that the STEAM approach breaks away from the fragmentation of knowledge by proposing integrated, contextualized projects based on inquiry, creativity, and real-world problem-solving. It also aligns with the "6Cs" global competencies, such as creativity, critical thinking, and collaboration, which correspond to the skills sought when employing CT (also recognized as dimensions of CT) (Andrade et al., 2026; Liu et al., 2023; Oliveira & Maia, 2026; Tripon, 2022).

In STEAM, the mathematics teacher must encourage students to engage in reflective processes during their learning and cognitive experiences to foster holistic development and the full exercise of citizenship; mathematics cannot merely serve as a useful tool for another field of knowledge but must stand complete in its own right, thus requiring a teaching approach that is active and transformative (Rodrigues-Silva & Alsina, 2023a; Rodrigues-Silva & Alsina, 2023b). Consequently, the problem under investigation must be relevant, authentic, and grounded in the real world, while allowing for diverse pathways or solutions, thereby making mathematics lessons transformative (Quigley et al., 2017). In this context, Maia and Soares (2025) define the self-referenced STEAM approach, focused on the Global South, as an investigative and creative pedagogical practice that is interdisciplinary in nature, holds the potential to achieve transdisciplinary, and centers on exploring real-world problems, particularly those arising from the students' own contexts.

Given this landscape, it is evident that Computational Thinking, alongside the STEAM approach, forms a promising foundation for developing integrative pedagogical practices aligned with the contemporary demands of basic education (Syafril et al., 2022). Beyond the scarcity of studies on this topic within basic education globally, as indicated by research, there is a need for proposals originating from and tailored to the Global South, taking into account unique socioeconomic, structural, and curricular realities, as well as specific educational technology contexts (Andrade et al., 2026; González-Pizarro et al., 2023; Maia & Soares, 2025). The proposal presented here is grounded in this understanding, bridging theory and practice through a didactic experience that aims to foster meaningful learning anchored in interdisciplinarity, real-world problem-solving, and the flexible strengthening of Mathematics' formative role within the school curriculum.

METHODS

This article analyzes the use of Computational Thinking (CT) in a STEAM pedagogical practice aimed at investigating a socio-environmental problem during Mathematics classes. The study participants were 32 second-year high school students (10 girls and 22 boys) from a state public school in Natal, Rio Grande do Norte, Brazil (Author, 2024). The project was developed within the scope of a master's research study employing the action research model (McKay & Marshall, 2001), which comprises eight stages: 1) Problem identification; 2) Literature review; 3) Action planning; 4) Implementation; 5) Monitoring; 6) Evaluation; 7) Refinement; and 8) Conclusion. For the purposes of this article, a specific segment of the work was selected, focusing on the use of Computational Thinking to develop a STEAM pedagogical practice, addressing a socio-environmental problem in high school Mathematics classes, with particular emphasis on stages 4 (Implementation), 5 (Monitoring), and 6 (Evaluation) as highlighted in Figure 1; further details on these stages can be found in the works of Author (2024) and Author et al. (2025a).

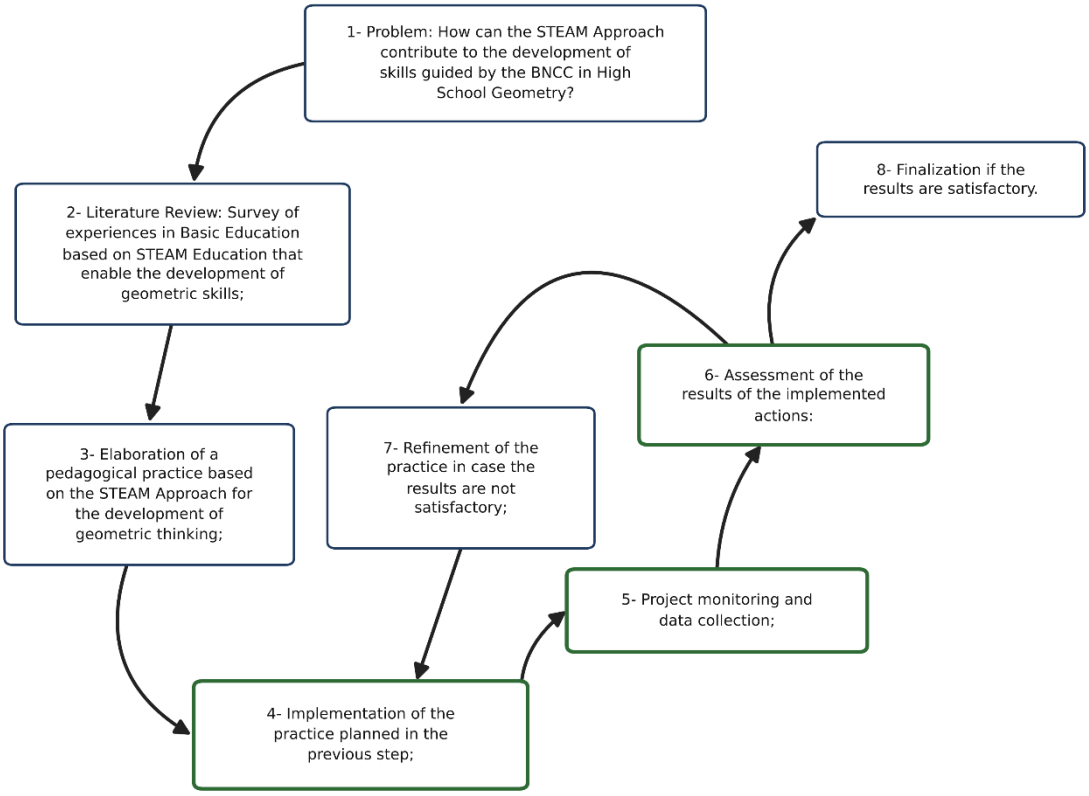


Figure 1. Action research model used in the study

Source: Author et al. (2025a).

The research methodology is applied in nature and qualitative in approach. Data analysis was conducted using data triangulation, integrating various forms of

evidence, images, questionnaires, pedagogical activities carried out by students, and the researcher's field diary observations, to identify convergences, divergences, and complementarities (Denzin, 1970). Furthermore, the results were interpreted and contextualized within the theoretical framework, enabling a discussion of the skills demonstrated by the students in light of various perspectives found in the literature.

To this end, the study presents an organized qualitative analysis of pedagogical practices, detailing how Computational Thinking (CT) and specific global competencies from the "6Cs" framework—creativity, critical thinking, and collaboration, manifested across four stages corresponding to the four pillars of CT as defined by Wing (2006): i) Decomposition; ii) Pattern recognition; iii) Abstraction; and iv) Algorithms. Ultimately, the article aims to answer the following guiding research question: How does Computational Thinking, combined with a STEAM approach, assist students in solving school-related problems?

The data collection instruments used in the master's thesis included multimedia recordings, such as a) audios, b) images, c) field diary, d) questionnaires, and e) pedagogical activities carried out by the students. Though this specific study utilized data collected from items (b), (c), (d), and (e).

The field diary contained textual notes based on the researcher's observations, comprising the following fields: date, location, objective, observations, benefits, difficulties, and discoveries (see Figure 7 and Figure 8). The questionnaire consisted of 16 items for students to answer; Table 1 presents the identification codes and their corresponding items.

Table 1. Questions from the questionnaire regarding student perceptions in the study

ID	Description of the questions
IT1	How old are you?
IT2	What is your sex?
IT3	1) What did you think of the class project investigating why pigeons inhabit the school sports court and seeking possible solutions to this issue?
IT4	2) Did you learn anything from the project?
IT5	3) Did you enjoy participating in the project?
IT6	4) What did you learn during the mathematics classes while carrying out the project? Describe it in your own words.
IT7	5) Did you learn anything from the project that is also related to other subjects?
IT8	6) Describe in your own words what you learned in other subjects that relate to the project (Physics, Chemistry, etc.).
IT9	7) Do you think the project showed how mathematics can be useful or applied in real-life situations?
IT10	8) In your opinion, how can mathematics be useful or applied in our daily lives?
IT11	9) What did you learn from the project classes? List at least 3 (three) things you learned.
IT12	10) What did you think about working collaboratively with your classmates during the project activities?

IT13	11) What did you think of the talk given by the alumnus who graduated in Architecture, and what did you learn from it?
IT14	12) Now that the class has finished the project, how would you define geometry?
IT15	13) How interesting did you find the project?
IT16	14) Write just one word below to describe the project classes:
IT17	15) Which of the following areas are you interested in pursuing professionally?
IT18	16) What did you like most about the project?
IT19	17) What were your biggest challenges during the project?
IT20	Do you have any suggestions? Write them here.

Source: Author (2024).

The Project-Based Learning (PBL) methodology was employed to support the pedagogical practice of the classes. Thus, the teaching sequence is understood as an organized and planned set of pedagogical activities aimed at student learning, activities that can be combined with active methodologies such as PBL (Santos et al., 2024).

To evaluate the teaching sequence, the BNCC skills mobilized by the students were identified and are detailed in Table 2. In total, five skills from the Mathematics and its Technologies area and three from the Computing area were observed.

Table 2. BNCC Skills

Skills in the area of Mathematics and its Technologies
(EM13MAT308) Apply metric relations, including the laws of sines and cosines or concepts of congruence and similarity, to solve and formulate problems involving triangles in various contexts.
(EM13MAT309) Solve and formulate problems involving the calculation of total surface areas and volumes of prisms, pyramids, and solids of revolution in real-world situations (such as calculating the material required for coating or painting objects whose shapes are compositions of the solids studied), with or without the use of digital technologies.
(EM13MAT314) Solve and formulate problems involving quantities determined by the ratio or product of other quantities, such as speed, population density, electrical energy, etc.
(EM13MAT201) Propose or participate in actions suited to regional needs, preferably within one's own community, that involve measurements and calculations of perimeter, area, volume, capacity, or mass.
(EM13MAT401) Convert algebraic representations of first-degree polynomial functions into geometric representations on the Cartesian plane, distinguishing cases of proportional behavior, with or without the use of dynamic algebra and geometry software or applications.
Computing Skills
(EM13CO19) Present, argue for, and negotiate proposals, products, and services using various media and digital tools.
(EM13CO21) Communicate complex ideas clearly using digital objects such as concept maps, infographics, hypertexts, and others.
(EM13CO09) Identify digital technologies, their presence, and forms of use in various activities within the world of work.

Source: Author (2024), adapted from the BNCC.

Table 3 shows the teaching sequence employed, including its objectives, description, number of lessons, technologies used, and the mathematical skills assessed, in accordance with the four stages corresponding to the four pillars of the CT.

Table 3. Summary of the teaching sequence

Stage	Objectives	Description	Number of classes	Technologies	Assessment
i) Decomposition	- Brainstorm possible solutions to the problem. - Break the solution down into smaller parts.	- Application of the brainstorming technique with the class to generate solutions; - Analysis of proposals and their feasibility; - Identification of dependent and independent variables.	1	Dry-erase marker, eraser, and whiteboard.	EM13MAT201
ii) Pattern recognition	- Determine the height of the sports court. - Identify patterns using mathematics.	- Application of Thales's Theorem and digital technologies (the "Measure" app, photography) to determine the height of the sports court.	2	Measuring tape, tape measure, smartphone.	EM13MAT308; EM13MAT314
iii) Abstraction	- Determine the height of the court. - Abstract data irrelevant to the solution.	- Application of the rule of three, ordered pairs on the Cartesian plane, and pixel variation of elements in a photograph to determine the court's height using relevant variables.	4	Dry-erase marker, eraser, whiteboard, laptop, projector, photograph, Paint program, Windows operating system, calculator.	EM13MAT314; EM13MAT401
iv) Algorithms	- Determine the total area of the safety net. - Interpret the safety net in both three-dimensional and two-dimensional terms. - Identify the sequential steps to calculate the total area.	- Create spatial and flattened representations of the safety net, including its dimensions. - Apply area formulas for the rectangle formed by the flattened surface of the safety net.			EM13MAT201; EM13MAT309.

Source: Adapted from Author (2024).

Figure 2 was created to highlight the relationship between the project stages, the STEAM areas, and the use of the CT throughout the process.

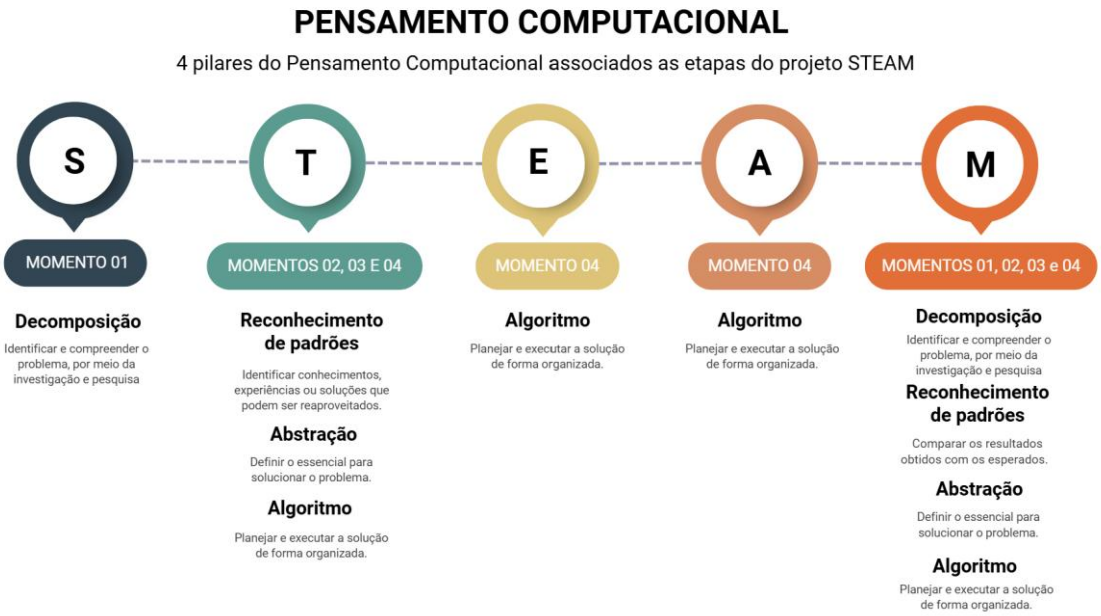


Figure 2. Relationship between STEAM areas and the four pillars of computational thinking throughout the project

Source: Own authorship (2026).

Thus, the methodological procedures described guided the course of the research and supported the analysis proposed in the article.

RESULTS AND DISCUSSION

This section presents the four stages carried out at the participating school, based on the four pillars of CT. It is worth noting that the CT pillars did not emerge in isolation or disconnected from one another during the process; rather, the analysis highlights where each became evident during the teaching sequence, following Wing (2006).

The participating students needed to seek viable solutions to a problem they had identified and selected within the school context: an overpopulation of pigeons inhabiting the metal framework of the sports court roof, which polluted the sports area with droppings, feathers, eggs, and dead pigeons scattered on the ground. To address this, the class had to consider the problem-solving process, and the CT framework guided the development of a solution. Using brainstorming technique, a method for generating new ideas and creative solutions collaboratively and without judgment, the students brainstormed solutions to the pigeon proliferation problem on the school court. Proposals mentioned by the class included covering the metal framework, cleaning up green waste in the surrounding area, raising awareness through school social media channels or banners and posters on the school façade, using sound trucks or distributing flyers to reach the local population, using pigeon repellents, and, their preferred option, installing protective netting over the sports

court. Thus, applying the brainstorming technique within a STEAM practice enabled the search for viable ideas and solutions to the problem. It fostered dialogue with and among students, encouraged critical and creative thinking and active listening, and highlighted the importance of collaboration in the process, thereby allowing them to mobilize global competencies or dimensions of CT (Liu et al., 2023; Author, 2024).

Furthermore, the brainstorming activity encouraged students to take an active voice and participate in decision-making while seeking a solution. The feasibility and utility of each proposal were discussed, ultimately leading to the selection of a protective net, a solution commonly used in other schools, such as the neighboring municipal school. Consequently, mathematical strategies were integrated into this process to obtain various measurements of the sports court and perform geometric calculations; these were used to analyze and quantify the impact of pigeon contamination in the area, specifically, the size of the contaminated zone, the area of the court's interior where the pigeons roosted, and the total protective netting required, thereby applying the "C" (Computing) component of STEAM (Syafril et al., 2022). In this context, specific variables had to be investigated and determined.

The students demonstrated the use of decomposition, the initial stage of the teaching sequence, when they realized that calculating the total area for the protective net required measurements of the sports court's length, width, and height, with the height presenting the greatest measurement challenge. They identified that determining the court's height was a necessary first step toward finding the total area. Algebraically, this involves variable dependency: determining the value of the dependent variable (total area) requires knowing all the independent variables (length, width, and height). The teacher then prompted them to propose alternatives for determining the height, focusing on the independent variables before addressing the dependent variable. Thus, they mobilized skills associated with standard EM13MAT201 and the scientific thinking inherent in the "S" (Science) of STEAM; through free expression, they applied investigative, mathematics-related thinking, incorporating the "M" (Mathematics) of STEAM, based on logical reasoning and concepts from previous lessons (Author, 2024; Author et al., 2024).

Learning through real-world problems using a scientific approach is a powerful tool for students in the classroom; while dealing with uncomfortable situations can be challenging, seeking strategies to rationalize the problem-solving process can make them more manageable. The teacher acts as a mediator in this process, and students actively construct knowledge while addressing the demands that arise along the way. Decomposition became evident when students visualized the smaller, distinct actions required to solve a larger problem, as seen in their comments below regarding the questionnaire items indicated in parentheses.

> Student 11: *I learned to look at problems differently, because that makes them simpler to solve (IT4).*
>
> Student 18: *I think that since we tried various ways to figure out the height of the sports court, if we ever need to do some home improvement—like needing to know the measurements of a room—we could use the methods we learned in class (IT10).*
>
> Student 19: *Measurement, because it's something we need to use a lot in our daily lives, even just to buy things like a wardrobe or a closet... (IT4).*

Here, the students are engaged in critical reflection, realizing that the problem could be broken down into smaller parts to facilitate decision-making. For instance, determining whether an object fits in a specific area requires measuring the installation site and carrying out other smaller actions to successfully achieve the goal.

In this process of thinking scientifically about how to measure height, the students moved to the second stage of the teaching sequence, Pattern Recognition, as, to the mathematics teacher's surprise, they suggested using Thales' Theorem. They had previously studied this theorem using simulations involving the shadows of various objects in the schoolyard at the beginning of the academic year. Consequently, the students recognized the similarity between the problem at hand and the legend of Thales' Theorem, in which Thales, at the pharaoh's request, had to determine the height of a pyramid. To do so, he reportedly used a rod or staff to find a shadow of equal length on the ground, comparing it with the pyramid and its own shadow, both cast by parallel solar rays. Although the students had tape measures and made several attempts at different times (10:00 AM, 12:00 PM, and 3:00 PM), they concluded that the positioning of the sports court on the school grounds made the measurements impossible. The court was built with its sides aligned east-west, leaving no space to take measurements in those directions due to surrounding walls; meanwhile, the front and back sections were aligned north-south, and their positioning meant they did not cast shadows suitable for measurement. Thus, the students discovered, both scientifically and experimentally, that this alternative was not viable. In doing so, they engaged skills EM13MAT308 and EM13MAT314, as well as mathematical pattern recognition, while devising solutions that mobilized the "M" (Mathematics) in STEAM (Custódio & Rosa, 2024) and the identification of regularities advocated by Liukas (2015).

Among the other alternatives, there were some using digital technologies. In one of these, a student suggested using a smartphone application, so they tested the "Medida" application on an iPhone, which was not efficient because it recorded a maximum height of 2.88 meters, very distorted from the apparently real height, and was therefore discarded. In this way, they mobilized the following Computer Science skill EM13CO19, as the students collectively argued for possibilities and proposed

some solutions, including using technologies and smartphone programs that are within their reach, thus exercising the student protagonism advocated by Selbach (2015).

The same student proposed another alternative: using the dimensions or quantities of known objects, such as comparing the height of the sports court to the dimensions of the wall's breeze blocks (*cobogós*) or to the height of a school basketball player using the court during class. Here, the students recognized that an object or a specific size could serve as a unit of measurement in various situations by applying the principle of proportionality between the objects under investigation, essentially using an object as a standard unit of measurement. However, since the breeze blocks were located only on the upper section of the wall, this option was ruled out, leaving the comparison of student heights as a viable approach. The student then suggested taking a photograph of a 1.82-meter-tall student to serve as a unit of measurement, allowing the class to determine how many such units would be required to reach the maximum height. Figure 3 shows the two proposals being tested for validation.



Figure 3. Students developing units of measurement while seeking solutions using digital technologies

Source: Author (2024).

Finally, the students concluded that the height of the court would be nearly 3.5 times their classmate's height, that is, 3.5 × 1.82 m = 6.4 meters. However, upon reflection, they realized there could be a margin of error of approximately half a meter because the method lacked precision; for instance, the angle of the photograph could influence the result, potentially bringing it closer to 6.9 meters. Consequently, they estimated the total height to be approximately 7 meters. They once again applied concepts of proportionality, a mathematical tool frequently used in classroom calculations involving the rule of three. This also engaged the

Computing skill EM13CO21, as the students were able to express their ideas logically and systematically using digital tools that are part of their daily lives. Thus, the "T" (Technology) component of STEAM was demonstrated through the conscious use of technology to devise strategies.

Pattern recognition was also evident in the students' comments, such as when they identified a pattern regarding the need to measure an available physical space before purchasing an item for their homes, by drawing parallels between other contexts and the project's practical measurement activities.

> Student 18: *I found it really interesting; in a way, it helps both the school and the neighborhood. This isn't a new problem, yet this is the first time a class and a teacher have dedicated themselves to it. Even the teachers who use the court don't seem to care, so it was a wonderful gesture by the teacher. And for me, since I play on the court all the time—solving this problem would be great (IT3).*
>
> Student 20: *I thought the idea was unique! But I also thought it was good—for society (IT3).*
>
> Student 18: *I think that since we tried various ways to determine the height of the sports court, if we ever need to do some home renovations and need to know room measurements, we could use the methods we learned in class (IT10).*

Recognizing that the problem involving pigeons is recurring, occurring not only at school but in various locations throughout the neighborhood, and understanding that a solution could benefit the entire community amounts to recognizing a pattern of a social issue. Furthermore, if a student can project the knowledge and actions developed onto other applicable contexts, they demonstrate an ability to identify a pattern across different situations.

To arrive at a more precise estimate of the court's height, the teacher suggested and guided the use of a computer program, specifically Windows Paint, building on the students' idea of using photographs to mobilize new mathematical and technological skills and competencies; this program is versatile and has applications in the professional world. At this stage, the students moved to the third phase of the instructional sequence, Abstraction, as, over several lessons, they used the mathematical concept of the "rule of three" to relate the photograph's pixel counts to the actual heights of the student and the court. Consequently, they had to select the relevant parameters and quantities for the calculations and set up the rule of three. For instance, since they were interested in height measurements, they concluded they only needed the pixel variations along the Y-axis (the vertical ordinate of the photograph's Cartesian plane), while disregarding the X-axis (the horizontal abscissa) as irrelevant to the calculations. They used the height of another classmate in the photo, $A_m = 1{,}76m$, with the height of the court being our unknown $A_q = x$,, along with the pixel variations corresponding to the boy's heigh

$\Delta_m = 660$ and the court's height $\Delta_q = 2764$ considering only the Y-axis dimension. During these lessons, the students revisited concepts regarding ordered pairs on the Cartesian planes specifically within the context of polynomial functions—relating their positions on the X and Y axes to the pixel locations in the Paint program. Ultimately, they estimated the height to be 7.37 meters, or approximately 7.5 meters. The students mobilized Computing skills (EM13CO09) by realizing how to use a digital technological tool and Mathematics to address a real-world societal problem—one potentially relevant to a future career—thereby aligning with Selbach's (2015) advocacy for making Mathematics meaningful to students. They also engaged skills EM13MAT314 and EM13MAT401 by applying proportionality relationships between quantities (the rule of three) and connecting them to polynomial functions, thus integrating mathematical concepts. Figure 4 illustrates these procedures.

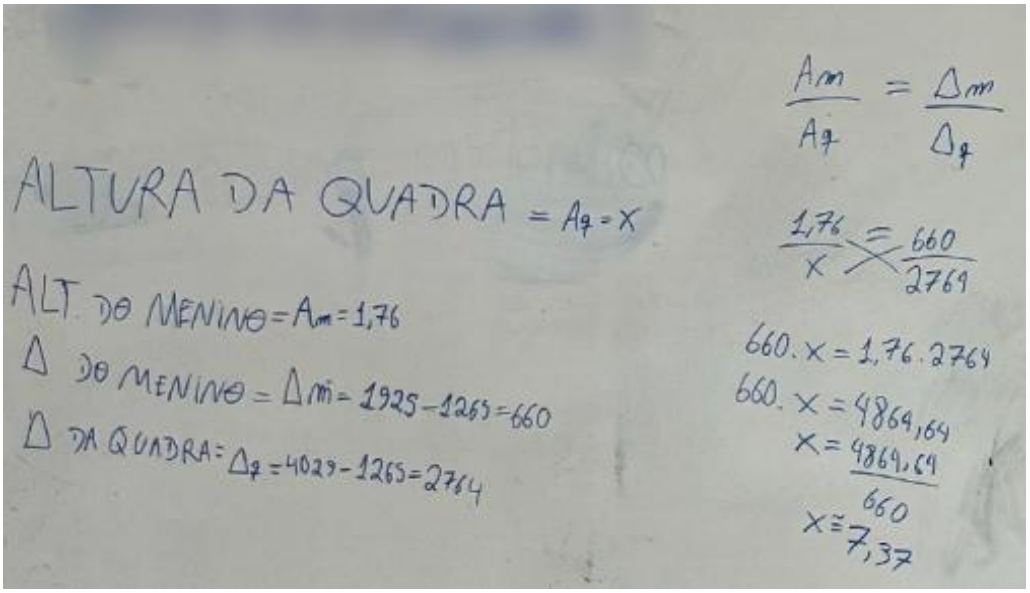


Figure 4. Calculations to determine the court height using the Paint program
Source: Author (2024).

The use of the "T" (Technology) from STEAM was once again observed through the purposeful application of digital technology to find viable solutions to problems encountered while constructing mathematical knowledge.

When performing geometric calculations in real-world situations or within subjects involved in inter- and transdisciplinary problem-solving—such as Physics, Chemistry, and Biology—students realized the need to measure only the necessary object dimensions or use specific parameters to meet their requirements, thereby eliminating unnecessary variables from the process. Thus, research indicates a pedagogical connection between Computational Thinking (CT) and STEAM when applied to the fields of Natural Sciences and Mathematics (Andrade et al., 2026).

> Student 22: *To buy a sofa, for example, we have to measure to see if it fits through the door; if you're putting up wallpaper, you have to measure to check the size (IT10).*
>
> Student 4: *Physics, being able to figure out the height of something just by the time it takes to fall (IT8).*

To determine the total area of the protective netting, the students followed specific steps to reach the desired result, moving into the fourth phase of the teaching sequence, Algorithms, as visualizing the solution and the netting required the following stages: First, drawing or representing it as a geometric solid (a rectangular prism) with its corresponding length, width, and height measurements; Second, representing it in a flattened, rectangular form, also with corresponding measurements, which required more complex reasoning, as the students recognized the relationship between the length of this flattened rectangle (the base, labeled "B") and the total perimeter required for the netting calculated in the previous stage (B = 95.26 m, the sum of twice the length and twice the width). Additionally, they correctly recorded the court's height (labeled "H") as 7.37 m on the representations they drew on the whiteboard; Third, the students used these measurements to calculate the final result (the total area of the protective netting, labeled "A"), as outlined in the initial "Decomposition" phase of the teaching sequence.

Thus, by determining the measurements of the independent variables (length, width, and height), it was possible to apply the rectangle area formula ($A = B \times H$) to calculate the dependent variable, the total surface area of the safety net, resulting in a value of 702.07 m^2. Based on this measurement, the financial cost of acquiring the safety net could be estimated (Author, 2024). Furthermore, this step-by-step design process encompasses both the students' creative work and collaborative interactions, drawing on the Social Sciences and Humanities (the "A" for Arts in STEAM), and the practice of conceptualizing and following a model, which underpins the "E" for Engineering in STEAM.

In addition to mobilizing the geometric skills EM13MAT201 and EM13MAT309, the process involved the following: according to Brackmann (2017), when seeking a solution, it is important that the steps be sufficiently clear for another person to understand and follow them. Figure 5 shows the algorithmic procedures used by the students.

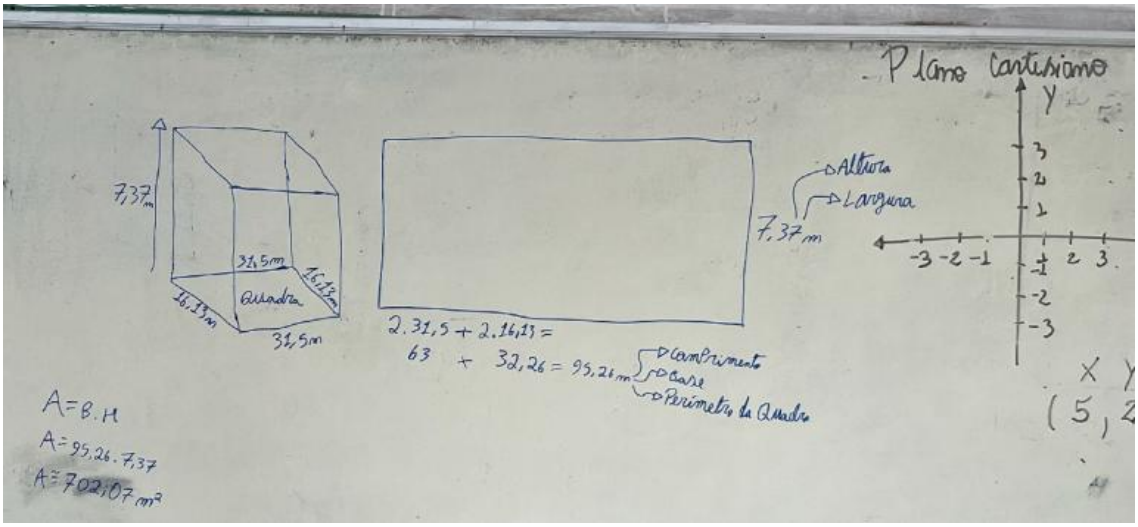


Figure 5. Final determination of the total area for the sports court safety netting

Source: Author (2024).

Carrying out these activities with the students required the use of various analog and digital resources, such as a marker, whiteboard, eraser, smartphone, and projector, to facilitate class viewing and participation, as well as a calculator to verify results and the Paint program (part of the Windows operating system) on a laptop belonging to the mathematics teacher. Figure 6 shows some of the resources being used by the students during practical activities.



Figure 6. Technological resources used in pedagogical practices

Source: Author (2024).

The application of the "T" (Technology) in STEAM became evident during the analyzed teaching sequence; it served to engage students in their classroom routine as they sought logical solutions to the problem. This enriched the practice by mobilizing various skills, such as critical thinking, creativity, argumentation, and collaboration, drawn from both Computing and Mathematics. Thus, Computational Thinking (CT) aided the problem-solving process at both conceptual and procedural levels, enabling students and the teacher to organize themselves and navigate the school routine and proposed activities.

In the administered questionnaire, students shared perceptions regarding the pedagogical strategies used in Mathematics classes, highlighting the cognitive computational skills involved in the STEAM project.

In their responses, students emphasized the use of specific methods to seek answers, results, and solutions, following necessary and important steps to solve the problems.

> Student 2: *It was interesting and quite unconventional, and I learned to use methods to solve the problem itself. It was very interesting (IT3).*
>
> Student 15: *I learned many things I didn't know before; I learned to calculate and add, and to share knowledge with my classmates, things I didn't know previously (IT6)*.
>
> Student 17: *Calculating using shadows and pixels, and performing scientific calculations (IT3).*

This way, it is evident that students understand that solving a specific problem involving calculations may require basic knowledge, such as the properties of fundamental mathematical operations like addition, as well as the ability to identify a logical order to ensure everything makes sense, connecting to the concept of algorithms.

Now, addressing the research question: How did Computational Thinking, combined with the STEAM approach, assist students in solving school-related problems? It is clear that CT is intrinsically linked, both implicitly and explicitly, to human thought processes; the more logically and rationally an individual's thinking is structured, the more it can aid in efficiency and effective problem-solving. The four pillars of the CT (Problem-Centered approach) were evident throughout the activities undertaken by the students and the mathematics teacher; the teacher guided her practice using a logical, sequential structure that facilitated the execution of each stage. Thus, the STEAM approach, which fosters the integration of various fields of knowledge within a real-world challenge, found a solid foundation in the CT framework when seeking a solution. Both approaches share a focus on problem-solving: STEAM guides the collective application of diverse knowledge, while the CT framework organizes that knowledge. Furthermore, the article indicates that the school community benefited from the creative, critical, investigative, and collaborative nature of the process, advancing their theoretical, experimental, and practical understanding while exploring the potential installation of a protective net to combat pigeon infestation on the school's sports court.

The researcher-teacher recorded research observations in a field diary, as shown in Figure 7 and Figure 8. This diary served to systematize and document key points from the project's lessons, facilitating later reference during the production of scientific materials.

Data	Local	Objetivo	Observações	Benefícios	Dificuldades	Descobertas
04/09/2023	Sala 2B	- Explicar sobre o projeto de mestrado - Explicar sobre a assinatura dos termos - Organização dos grupos - Apresentação do Prêmio Liga STEAM 2023 e ODS.	Criar os grupos do projeto, grupos de administração e geral pela Estudante 19, decisão dela do grupo de administração.	Proatividade dos alunos na organização dos grupos.	Teve alunos que faltaram no dia que tiveram que ser alocados em grupos.	Os estudantes ficaram interessados na proposta.
11/09/2023	Sala 2B	Apresentação do projeto - Liga STEAM - ODS - Fases do projeto - Assinatura dos termos e autorizações de voz e imagem.	Participação de alguns estudantes dizendo para matar os pombos, agitação de alguns alunos levando o tema de forma não séria.	A maioria dos estudantes se mostraram interessados em resolver o problema de forma geral.	A conscientização de alguns estudantes de que não podemos interferir na natureza agindo com violência contra os animais.	Mudança de atitude dos estudantes que se interessaram em encontrar estratégias sem envolver violência contra os animais como soluções sustentáveis.

Figure 7. Perceptions, observations, and notes from the researcher-teacher

Source: Author (2024).

Figure 8 presents an excerpt from the researcher-teacher's field diary, translated into English for presentation in this article.

Date	Location	Objective	Observations	Benefits	Difficulties	Discoveries
04/09/2023	Room 2B	- Explain the master's project - Explain the process for signing the terms. - Organization of groups Presentation of the 2023 STEAM League Award and the SDGs.	The project groups, administration groups, and general group will be created by Student 19, a decision made by her regarding the administration group.	Students' proactivity in organizing groups.	There were students who were absent on the day they had to be placed into groups.	The students were interested in the proposal.
11/09/2023	Room 2B	Project presentation Steam League SDGs Project phases - Signing of the terms and authorizations for voice and image use.	Participation of some students saying to kill the pigeons, agitation of some students taking the subject in a non-serious way.	Most students showed interest in solving the problem in general.	Raising awareness among some students that we cannot interfere with nature by acting violently towards animals.	A shift in attitude among students who became interested in finding strategies that do not involve violence against animals as sustainable solutions.

Figure 8. Translation of the researcher-teacher's perceptions, observations, and field notes

Source: Author (2024).

By cross-referencing data from the field diary and the student questionnaire, it is evident that the information gathered and knowledge constructed during the project's various activities better equipped students to draw critical inferences about their lived reality, whether individual or collective. This demonstrates that the project impacted their lives and shifted the perceptions of both the students and the local community. Thus, the STEAM project broadened the students' curricular perspective; technology did not become an end in itself or the project's sole focus, but rather a tool that aided in the search for sustainable solutions, as evidenced by their statements:

> Student 2: *"Working as a team, being responsible, and not giving up" (IT11).*
>
> Student 3: *It was an incredible project that not only taught us a bit more mathematics but also allowed us to help the community in some way by seeking solutions. Whether intended or not, these solutions helped the school, the community, and the students themselves; and by seeking solutions, we also learned how to protect ourselves against diseases and take preventive measures (IT3).*
>
> Student 5: *Never feed the pigeons; never sweep up droppings without wetting the ground first, because the dust is contaminating; never leave trash in abandoned areas (IT11).*
>
> Student 6: *I thought it was important because this topic isn't really discussed by neighborhood residents, who often suffer the consequences of the pigeon problem without knowing why; I think the project is a way to raise awareness (IT3).*
>
> Student 8: *I learned the importance of protecting the school; I learned physics by calculating the height of a sports court; and I learned mathematics through building a scale model and creating a project blueprint (IT6).*

The most notable recurring theme in the field diary records was the students' commitment to resolving the socio-environmental issue in a way that was sustainable for everyone, while also meaningfully incorporating mathematics. The process of raising student awareness was gradual, as they did not know the best way to address the issue of personal and collective hygiene, nor did they grasp the severity of the situation, failing to perceive any immediate, direct, or serious associated risks, as illustrated in Figure 7 and Figure 8

Overall, the STEAM project fostered problem-solving through an inter- and transdisciplinary approach involving Natural Sciences and their Technologies (Biology, Chemistry, and Physics), areas explored in greater detail in previous studies such as Author et al. (2025a) and Author et al. (2025b). Furthermore, the research provided an opportunity to delve deeper into the use of Computational Thinking (CT) in STEAM practices within Latin America, a region also considered part of the Global South (Andrade et al., 2026; González-Pizarro et al., 2023; Maia &

Soares, 2025). Active teaching methods encouraged students to take a stance, make decisions, and fully utilize mathematics to solve problems using computational strategies (Quigley et al., 2017; Rodrigues-Silva & Alsina, 2023b; Tripon, 2022).

CONCLUSION

The analysis presented in this article fosters critical reflection on the use of Computational Thinking (CT) in schools, particularly by teachers who, through direct interaction with students, can develop innovative, scientifically grounded pedagogical practices focused on real-world needs, supported by the STEAM approach and technological advancements (both digital and non-digital). The study contributes to the understanding that while CT does not necessarily require the use of digital technologies, it does not overlook their pedagogical relevance either. Regardless of the subject area or educational level, the four pillars of CT are applicable, provided there is proper planning and support from school management and coordination, as they relate to the workings of human thought. Thus, CT can contribute to students' holistic development by fostering creative, critical, and collaborative processes. In short, through a STEAM project utilizing Computational Thinking, 2nd-year high school students at [omitted for blind review] had the opportunity to seek solutions to the problem of pigeon proliferation on the school sports court in a systemic, organized, and scientific manner; in doing so, they mobilized mathematical and computational skills outlined in the BNCC (National Common Curricular Base), as well as global competencies such as critical thinking, creativity, and collaboration throughout the project activities.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

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