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Between pirates and astronauts: developing computational thinking in the 4th and 5th grades of elementary school through unplugged material

EDUCATIONAL PRODUCT

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Abstract
This paper describes and analyzes the development and contributions of a concrete teaching material for the introduction of computational thinking in the 4th and 5th grades of Elementary School. For this purpose, two teaching resources were developed, advocating unplugged computing and meeting the elements provided for in the National Common Curricular Base for these grades. Thus, the materials enable the introduction of concepts related to "algorithms with nested simple repetition" and "algorithms with conditional selection" through problems that consist of developing paths on thematic boards with the help of movement cards. The material was applied in a public school in the municipal network of Nova Andradina - MS, with classes selected by the pedagogical coordination. The results show that the students understood the concepts worked on in the material and engaged in the proposed situations, mobilizing their reasoning to solve the problem and pointing out new ideas for future use of the resource.
Keywords: Teaching Material. Educational Games. Computer Science and Education.

Entre piratas e astronautas: desenvolvendo o pensamento computacional no 4º e 5º anos do Ensino Fundamental por meio de um material desplugado

Resumo
Este trabalho descreve e analisa o desenvolvimento e as contribuições de um material didático concreto para a introdução do pensamento computacional no 4° e 5° anos do Ensino Fundamental. Para isso, foram elaborados dois recursos pedagógicos, preconizando a computação desplugada e atendendo aos elementos previstos na Base Nacional Comum Curricular para as referidas séries. Assim, os materiais permitem a introdução de conceitos relacionados a "algoritmos com repetição simples aninhadas" e "algoritmos com seleção condicional" por meio de problemas que consistem na elaboração de percursos em tabuleiros temáticos com o auxílio de cartas de movimentação. A aplicação do

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material ocorreu em uma escola pública da rede municipal de Nova Andradina – MS, com turmas selecionadas pela coordenação pedagógica. Os resultados denotam que os estudantes compreenderam os conceitos trabalhados no material e se engajaram nas situações propostas, mobilizando o raciocínio para a solução do problema e apontando novas ideias para uso futuro do recurso.
Palavras-chave: Material Didático. Jogos Pedagógicos. Informática e Educação.

1 Introduction

Computer education has become an increasingly established necessity within the school context. The rapid pace of technological development, combined with new habits shaped by ever more accessible resources, brings with it new demands for the educational environment, from the early years of schooling to higher education. According to Vieira and Hai (2022, p. 2), "thinking about the Cyberculture that drives our contemporary world is a challenge for researchers worldwide, especially when we consider education."

According to Salgado *et al.* (2023, p. 74), "research, development, and practice in twenty-first-century computing must respond to the need for digital literacy among the Brazilian population." In this sense, initiatives have been undertaken to incorporate computer education into the Brazilian school curriculum. In 2019, the Brazilian Computer Society (SBC) systematized a set of guidelines outlining what can be addressed at each grade level (Ribeiro *et al.*, 2019), emphasizing problem-solving through computational thinking (CT).

In 2022, another step forward was taken with the publication of the *Standards on Computing in Basic Education: Complement to the National Common Curricular Base* (Brazil, 2022). This document, an addendum to the BNCC (Brazil, 2018), organizes learning objectives, knowledge areas, and skills for each grade level, from Early Childhood Education to High School.

Within this context, it is important to consider the incorporation of CT across different curricular units. Wing (2006; 2016), a computer scientist at Columbia University who coined the term, advocates for the importance of CT in the personal and professional development of Basic Education students. She identifies its core pillars as decomposition,

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pattern recognition, abstraction, and algorithm design, which are used to solve problems and support learning across various fields of knowledge.

> Computational thinking involves problem-solving, system design, and understanding human behavior through the extraction of fundamental concepts from computer science. Computational thinking includes a set of mental tools that reflect the vastness of the computer science field (Wing, 2016, p. 2).

Glizt (2020) highlights that the development of logical reasoning among students remains a concern, as such difficulties can persist into higher education if not properly stimulated. “Unlike regular school subjects such as Portuguese and mathematics, the teaching of logic is not considered a specific discipline in the early years” (Glizt, 2020, p. 408).

Implementing CT is not a simple task, since teachers often lack proper training and there is a shortage of adequate teaching materials. Therefore, it is essential to invest in both initial and continuing teacher education, as well as in the development of pedagogical resources appropriate to students’ cognitive levels, in order to ensure that this skill becomes a genuine and effective classroom practice.

From this perspective, the present study describes the results of a project aimed at analyzing the contributions of an unplugged instructional material for learning introductory programming concepts in the early years of elementary school. Through the creation and application of this material, we sought to identify its pedagogical potential for introducing CT to students, as well as its limiting factors.

The project developed and validated four pedagogical resources, each tailored to the specificities of a grade level (from 2nd to 5th grade). This paper focuses its analysis on the materials developed for the 4th and 5th grades, respectively.

To facilitate a better understanding of the results, this text is organized as follows: Section 2 presents a brief theoretical review, summarizing the main authors who support the educational product and its application; Section 3 describes the methodological path taken; Section 4 presents the results obtained, detailing the materials developed and

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analyzing the impacts of their implementation; and finally, the concluding remarks and references are presented.

2 Brief theoretical review

2.1 Computational thinking and unplugged computing

In synthesizing Brazilian publications on the subject, Carvalho and Braga (2022, p. 240) argue that, despite the lack of an exact definition of CT, “there are some shared understandings of the term, as it is related to problem formulation and resolution, the ability to organize data logically, and to conceive a solution that can be interpreted and executed by a computer.”

According to Glizt (2020, p. 411), CT “aims to develop logical reasoning by providing the means to solve a problem through its division into subproblems, which tend to make its resolution easier and more innovative.” In this regard, Wing (2016) points out that CT includes mental tools that reflect the vastness of this field of knowledge within computer science.

> Computational thinking is based on the power and limitations of computational processes, whether executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that none of us would be able to tackle alone (Wing, 2016, p. 2).

Ribeiro, Foss, and Cavalheiro (2020) argue that understanding the concept of CT requires comprehension of what computing is, since the formalization of reasoning is closely related to problem-solving. In this context, CT can be conceived “as a generalization of logical reasoning: a process of transforming inputs into outputs, in which the inputs and outputs are not necessarily true statements, but any kind of object [...]” (Ribeiro, Foss, and Cavalheiro, 2020, p. 16).

The concepts related to CT are aligned with Seymour Papert’s constructionism. Papert, a scientist who, as early as the 1980s, demonstrated that children could program

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computers (Papert, 2008), based his ideas on the premise that learning should be built by the student rather than merely transmitted by the teacher. The teacher, in turn, should encourage students to develop problem-solving and creative thinking skills (Hai *et al.*, 2023).

In his dissertation, Brackmann (2017, p. 33) summarizes the four main concepts involved in CT:

- *Decomposition*: identifying a complex problem and breaking it into smaller, more manageable parts;
- *Pattern recognition*: analyzing each of these smaller problems more deeply to identify similar issues that have already been solved;
- *Abstraction*: focusing only on the details that matter while ignoring irrelevant information;
- *Algorithms*: creating simple steps or rules to solve each of the subproblems identified.

It is generally agreed among scholars that CT is not limited to computing and can be applied across all areas of knowledge. Wing (2011) notes that CT has also begun to influence disciplines and professions beyond computer science and engineering. For example, she cites active fields such as algorithmic medicine, computational archaeology, computational economics, computational finance, computational journalism, computational law, computational social science, and digital humanities. She further emphasizes that data analysis is used in military training, spam and credit card fraud detection, service recommendation and quality ranking, and even in the personalization of coupons at supermarket checkouts.

> [...] Computational biology is changing the way biologists think. Similarly, computational game theory is changing the way economists think; nanocomputing, the way chemists think; and quantum computing, the way physicists think. This type of thinking will become part of the skill set not only of other scientists but of all people. Ubiquitous computing is to today what computational thinking is to tomorrow. Ubiquitous computing was

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> yesterday's dream that became today's reality; computational thinking is tomorrow's reality (Wing, 2016, p. 4).

Another point worth highlighting is that it is not necessary to use computers to address various topics related to computing. In this sense, so-called unplugged computing emerges as a potential pedagogical tool, particularly when considering socioeconomic factors that often hinder access to technology. Oliveira, Cambraia, and Hinterholz (2021) describe unplugged computing as an approach that encompasses the development of computing activities through non-digital means, using unconventional materials, "[…] enabling a work plan without the need for extensive technological apparatus and fostering a multidisciplinary environment through engaging activities for students." They also point out the growing number of studies on the subject, underscoring the need for a more detailed analysis of the results obtained.

In summary, although it is a relatively recent term, CT is grounded in a theoretical field that has been evolving for decades, namely Papert's constructionism (2008), which dialogues with different learning theories such as the historical-cultural theory (Vygotsky, 2008) and genetic epistemology (Piaget, 2010). It thus constitutes an important and contemporary framework of concepts and principles that can substantially contribute to educational processes. At the same time, it represents an approach whose implementation requires analytical attention to its results, particularly regarding its systematization as an educational practice within the context of formal education.

2.2 Computational thinking in Elementary Education

In investigating how CT can be integrated into school curricula—connecting education to the digital world beyond the mere use of electronic devices—Vieira and Hai (2022, p. 2) emphasize that "the contemporaneity of Cyberculture has presented us with the challenge of providing this audience with tools that allow them to make unlimited use of knowledge and practices." At the same time, Hai *et al.* (2023) warn of the increasing participation of children in a universe dominated by games and social media, which carry with them a reductionist view of technology, limiting it to cell phones and tablets as mere access tools. “This places children and adolescents within a massive consumer market that shapes their views of themselves and others, without truly understanding, apprehending, or even mastering technology” (Hai *et al.*, 2023, p. 6).

> It is therefore essential to provide CT concepts to everyone, regardless of gender, social class, or race, as a means of promoting more inclusive education. Each student must play an active role in the teaching and learning process and, for this to occur naturally, must feel like an integral part of that process. Thus, the ability to include sociocultural dimensions such as gender, social class, and race, for instance, is a factor that should be encouraged in these activities (Salgado *et al*., 2023, p. 74).

As previously discussed, CT has applicability across multiple fields. Mendes *et al.* (2020) point out that numerous studies have been conducted with the goal of incorporating it into elementary and secondary school curricula. However, they also highlight the challenges that remain concerning the complexity of learning these concepts, from both the student’s and the teacher’s perspectives, particularly regarding the pedagogical approaches to be adopted in educational contexts.

In her master’s research, Glizt (2020) explores CT in the early years of elementary education. Her aim was to examine how CT contributes to enhancing students’ logical reasoning. To that end, she developed lesson plans to teach children introductory computer science concepts. The study was structured around the following themes: numerical base conversion, image representation, systematic questioning, algorithm interpretation and execution, problem abstraction, and problem-solving. The research was conducted with a 4th-grade class, which achieved positive results. Her conclusions indicate that:

> [...] the learning of computational concepts as presented attracts children’s curiosity and encourages them to find quick solutions to different problems. The research presented here showed that, beyond learning concepts related to computer science, children understood the possibility of developing mechanisms of interaction and discovery through the machine, allowing them to act upon the computer rather than merely using the resources already available in the device (Glizt, 2020, p. 438).

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Brackmann *et al.* (2020) conducted a systematic literature review on CT implementation initiatives in formal and informal education in various countries. They note that, in Brazil, educational policies are still incipient and focused on digital literacy and inclusion. Nevertheless, organizations such as the SBC are actively engaged in introducing computational thinking, digital technology, and digital culture as part of a large national project.

In this regard, as previously mentioned, the greatest advancement of these initiatives was the inclusion of CT in the BNCC (Brazil, 2022). Table 1 presents an excerpt of what is established for the 4th and 5th grades of elementary education, which constitute the context of the project described here and the foundation for the educational product developed and implemented.

Table 1 – Computational Thinking in the BNCC: 4th and 5th Grades – Elementary Education

Stage	**Knowledge Object**	**Skills**
4th grade	Matrices and records	(EF04CO01) Recognize real-world and/or digital objects that can be represented through matrices establishing an organization in which each component is positioned according to defined coordinates, performing simple manipulations of these representations.
		(EF04CO02) Recognize real-world and/or digital objects that can be represented through records establishing an organization in which each component is identified by a name, performing manipulations of these representations.
	Algorithms with simple and nested repetitions	(EF04CO03) Create and simulate algorithms represented in oral, written, or pictographic language that include sequences and simple or nested repetitions (defined and undefined iterations) to solve problems independently and collaboratively.
5th grade	Lists and graphs	(EF05CO01) Recognize real-world and/or digital objects that can be represented through lists establishing an organization in which a variable number of items are arranged sequentially, performing simple manipulations of these representations.

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		(EF05CO02) Recognize real-world and/or digital objects that can be represented through graphs establishing an organization with a variable number of vertices connected by edges, performing simple manipulations of these representations.
	Computational logic	(EF05CO03) Perform operations of negation, conjunction, and disjunction on logical statements and values ‘true’ and ‘false’.
	Algorithms with conditional selection	(EF05CO04) Create and simulate algorithms represented in oral, written, or pictographic language that include sequences, repetitions, and conditional selections to solve problems independently and collaboratively.

Source: Adapted from Brazil (2022).

The document is based on the premise that “Computing allows for the exploration and experience of learning processes, always driven by playfulness through interaction with peers” (Brazil, 2022, p. 1). In this context, from a curricular standpoint, Brazil has already incorporated CT in a systematic way, leaving it to public policies to ensure its implementation in schools and its integration into teachers’ educational practices.

2.3 Computational thinking and gamification

Another important aspect when discussing the characteristics of CT relates to its synergy with gamification as a pedagogical practice. The challenging stimulus of problem-solving and the engagement in activities are essential elements in any proposal that aims to develop CT, regardless of the level of education.

According to Quast (2020, p. 791), gamification can be defined as “the design of meaningful learning experiences through the use of game elements and logic, with the purpose of achieving a goal and providing direction, purpose, and meaning to participants’ actions.” In this sense, Oliveira (2025, p. 55) points out that “the potential of gamification as an educational practice lies in generating differentiated alternatives for knowledge construction, considering that students learn in different ways.” Thus, when viewed as a pedagogical strategy, gamification can serve as a tool (means) to stimulate the development of CT (end), as shown in the studies described below.

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Del Olmo-Muñoz *et al.* (2023) investigated the impact of gamification techniques on CT skills and on the intrinsic and extrinsic motivation of second-grade students through a hybrid teaching sequence that combined unplugged and plugged CT activities. The main results highlight that both shallow and deep gamification techniques can effectively enhance CT skills in young students, though deep gamification may have a stronger impact on motivation.

Stadler *et al.* (2024) describe the results of a teaching experiment that investigated CT development through the use of a platform offering problem-solving activities in a playful context using block-based programming. Their findings indicate that block-based programming, when involving problem-solving within a gamified context, has strong potential for developing CT skills. However, it is worth noting that this experiment was conducted with high school students.

Cunha, Aguiar, and Barbosa (2024) analyze the advantages of gamification and its association with the introduction of CT in elementary education through the development of an educational game. Preliminary results indicate positive acceptance of the game by teachers involved in its validation, but they emphasize the need for deeper implementation involving students in a real educational setting.

Drawing on Wing (2006), Brazil (2022), Brackmann (2017), and Deterding *et al.* (2011), Table 2 presents a comparative systematization of key aspects concerning gamification and CT.

Table 2 – Relationships Between Computational Thinking and Gamification

Aspect	**Gamification**	**Computational Thinking**
Definition	Use of game elements in non-playful contexts to engage and motivate.	Problem-solving process based on computer science practices.
Objective	Increase engagement, motivation, and participation in activities beyond entertainment.	Develop cognitive and metacognitive skills for analyzing, structuring, and solving problems.
Pillars	Points, badges, levels, immediate feedback, progressive challenges, narrative.	Decomposition, abstraction, pattern recognition, and algorithms.
Cognitive dimension	Extrinsic stimulation (rewards) and intrinsic stimulation (immersion, sense of progress).	Logical reasoning, creativity, abstract and strategic thinking.

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Pedagogical use	Means to motivate and promote engagement across different curricular units.	Cross-disciplinary competence applied in various fields of knowledge.

Source: Adapted from Wing (2006), Brazil (2022), Brackmann (2017), and Deterding et al. (2011).

In summary, there is a clear element of complementarity between gamification and CT. Therefore, it becomes essential to consider, even partially, the inclusion of gamified elements in materials designed to foster the development of CT among students at any educational level.

2.4 Teaching materials for the development of Computational Thinking

According to Ceratti and Nóbile (2023, p. 133), the inclusion of CT in school curricula “is a global phenomenon that transcends borders and is driven by the growing understanding that computing-related skills are essential to preparing students for the present and future world.” From this perspective, it is clear that initiatives aimed at concretizing this curricular integration are necessary.

A search conducted in the *Catalog of Theses and Dissertations* of the *Coordination for the Improvement of Higher Education Personnel* (CAPES) revealed that, in Brazil, master’s and doctoral research involving CT in Basic Education has largely focused on practices, activities, and strategies. Within this context, 202 studies were identified.

Specifically regarding teaching materials and/or unplugged educational resources, the number is considerably smaller. In the initial search, 12 studies were found. However, after refinement, only two dissertations met the inclusion criteria (unplugged teaching materials focused on CT in Basic Education): Lima Filho (2022) and Silva (2024). Most of the other studies addressed educational robotics, using equipment such as *Arduino*® or specific kits.

Lima Filho (2022) presents a range of activities and artifacts—original or adapted—that can be used, improved, or serve as inspiration for teaching and learning through a combination of practice and theory within an interdisciplinary approach, emphasizing

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experimentation and critical analysis. However, the application was carried out with undergraduate students in Computer Science Education at UFRPE, in the distance learning modality, and not directly with Basic Education students.

In her dissertation, Silva (2024) describes the results of a didactic proposal designed to foster CT through online and offline unplugged activities. Although it makes use of some tangible materials, two aspects are worth noting, given the focus of our review: there was no actual development of a teaching material per se, and the research was conducted with high school students.

In a comparative analysis of the documents guiding CT in Brazilian Basic Education—the BNCC (Brazil, 2018; 2022) and the *Guidelines for Teaching Computing in Basic Education* (Ribeiro *et al.*, 2019)—Kniphoff da Cruz *et al.* (2023) emphasize that the skills and knowledge objects outlined therein should be taken into account when developing unplugged teaching materials, considering the educational level and grade of the target students. They also argue that it is essential to promote discussions about how Computing education should be implemented in Basic Education schools, noting that the BNCC supports a gradual, year-by-year implementation process for schools with fewer resources, which excludes a significant portion of current students. To address this gap, they suggest "the implementation of a pilot project with specific teaching materials that enable the teaching of Computing in certain grades of elementary and high school, especially for students completing the ninth grade of elementary education and the third year of high school" (Kniphoff da Cruz *et al.*, 2023, p. 346).

In summary, there is a clear need for more initiatives that advance the analysis and production of concrete, specific materials, whether plugged or unplugged. At the same time, it is understandable that most existing studies focus on methods and techniques, as practice necessarily precedes resource development. Within this context, previous research can serve as a foundation for the creation and evaluation of concrete tools that facilitate such development. It is also likely that, in the context of university extension projects or scientific initiation at the secondary or higher education levels, there are more

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initiatives focused on the creation of teaching materials. However, our objective in this review was to analyze master's and doctoral research conducted in Brazil.

3 Methodology

The project followed a qualitative approach, descriptive-explanatory in nature and interventionist in character (Gil, 2021a; 2021b). In this context, we sought to gather opinions, understandings, and attitudes regarding the content addressed, as well as to analyze how the material assisted students in understanding CT.

The methodological path consisted of the following stages: theoretical review, development of the teaching material, planning of its application, implementation of the material, and collection and analysis of students' feedback. The site for the application and validation of the material was a municipal public school in Nova Andradina, MS, and the participants were 4th- and 5th-grade elementary school students. The instruments used for data collection were participant observation (Marietto, 2018) and reflective interviews (Szymanski, 2018).

Table 3 systematizes the relationship between the indicators and the instruments defined for the data collection process..

Table 3 – Indicators and Data Collection Instruments

Indicator	Instrument
1) What are the main concepts related to Computational Thinking? 2) What aspects of Computational Thinking should be addressed in the 4th and 5th grades of elementary education? 3) What elements should be considered in the development of a tangible teaching material?	Theoretical and/or documentary review
4) What was the students' experience using the proposed material? 5) What did students understand about Computational Thinking after interacting with the proposed material? 6) Which aspects of the proposed material contributed to the students' initial understanding of Computational Thinking?	Observation / Interview

Source: The authors (2024).

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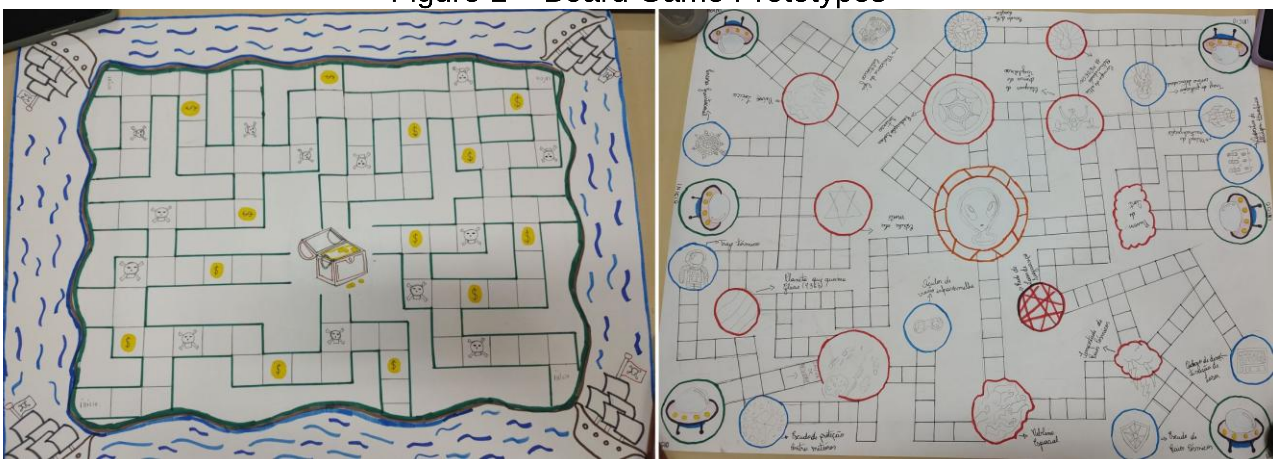
The first stage consisted of the theoretical review. We sought academic works related to the topic of investigation, prioritizing those that addressed the creation of teaching materials for the development of CT, in order to understand the essential elements of such a process. In addition, we participated in an introductory extension course aimed at deepening our conceptual understanding to better support the development of the teaching material.

After completing the first stage, we proceeded to the creation of the pedagogical product. We analyzed possible themes for each game board, their complexity, rules, and every element related to the design process, always considering the concept of CT and how it would be applied. Based on this analysis, prototypes of the boards were developed, as shown in Figure 1. These prototypes were discussed, evaluated, and ultimately validated in regular advisory meetings. At the same time, the narrative supporting each of the materials was written and refined.

Figure 1 – Board Game Prototypes



Source: The authors (2024).

Once the board game prototypes were approved, we proceeded to design the command cards required for the material, as well as the special consequence cards that are part of each educational product.

The final version of the boards was created by a professional designer, who developed the graphic artwork using professional design software. The artwork was

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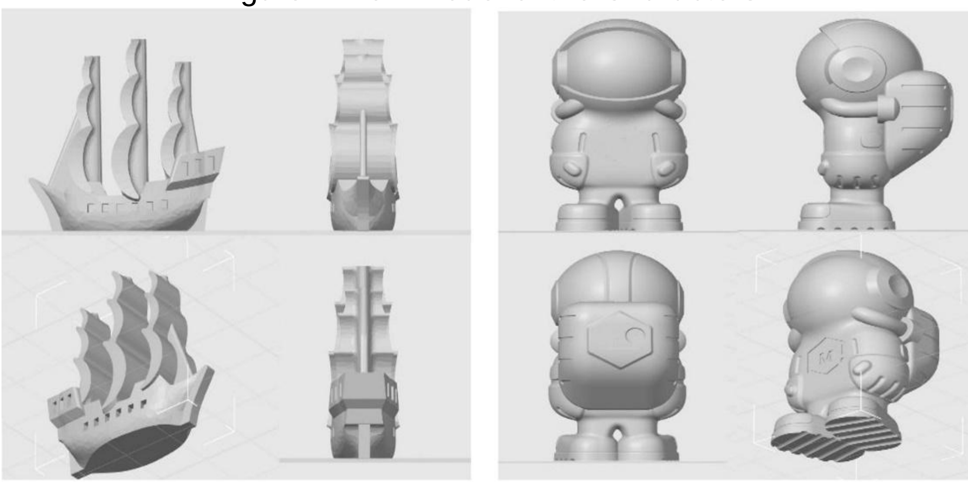
designed for printing on vinyl banners, since the material would be handled by children. Therefore, it was necessary to ensure not only high visual quality but also sufficient durability for frequent use.

The cards were produced using polyvinyl chloride (PVC) bases, with the artwork printed on 180 g/m^2 paper, then glued and laminated with *contact paper* to improve resistance and durability during handling. Finally, 3D prints of the game characters were produced. Figure 2 illustrates the 3D printing models of the pieces, which were obtained free of charge from the *Thingiverse*® platform[1].

Figure 2 – 3D Model of the Characters



Source: The authors (2024).

To support teachers, a guide was developed for each material, providing information about the rules, the minimum and maximum number of players, objectives, and the quantity of each type of card. It also included didactic sequences designed to facilitate the understanding and classroom application of the material.

Once all materials were completed and the implementation plan finalized, the pedagogical product was applied to students through workshops. During this process, we worked alongside classroom teachers to minimize any sense of unfamiliarity caused by the

[1] https://www.thingiverse.com.

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presence of external participants in the school environment. As previously described, our main data collection tools were observation and interviews. Figures 3 and 4 show moments from the implementation of the material with 4th- and 5th-grade students, respectively.

Figure 3 – Material Implementation (4th Grade)

Source: The authors (2024).

Figure 4 – Material Implementation (5th Grade)

Source: The authors (2024).

The 4th-grade session took place on September 11, 2024, with a class of 31 students. The 5th-grade session was held on September 9, 2024, with 29 students. Each session lasted two and a half hours.

After the implementation, the participating students took part in a group interview to identify their understanding of the introductory concepts addressed, as well as their

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opinions about the educational product. Table 4 presents the set of questions used during this stage of data collection.

Table 4 – Post-Implementation Interview Questions

Part A – About the activity	Part B – About the material
1) What did you learn today? 2) Were you able to complete the challenge? 2a) Yes: How did you do it? 2b) No: How far did you get? What was difficult? What would you do differently? 3) Do you think it is possible to create other challenges using this material? 3a) Yes: Which ones? 3b) No: Why not?	4) Did you like the material? 5) What caught your attention the most? Why? 6) Would you like to keep using the material? Why? 7) Would you like your teacher to continue using the material with you? 7a) Yes: What could they do with you? 7b) No: Why not?

Source: The authors (2024).

Finally, the results were analyzed. In this last stage, we organized, categorized, and examined the data collected in the previous phases, interpreting them according to the indicators previously established for the study.

The project was duly approved by the Research Ethics Committee of the *Universidade Católica Dom Bosco* (UCDB), under protocol CAAE 81356224.3.0000.5162. Since the participants were minors, informed consent and assent forms were properly signed by their legal guardians through coordination with the school's pedagogical team.

4 Results and Discussion

4.1 Material for the 4th grade

The material designed for the 4th grade consists of a path-based challenge in which an objective is defined and a route must be planned and followed by the game pieces. It is titled *The Adventure of the Lost Binary Treasure* and focuses on the knowledge object "algorithms with simple and nested repetitions." The selected skill corresponds to EF04CO03, as previously described in Table 1. **Figure 5** shows the board used in this activity along with its respective pieces.

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Figure 5 – Board for the 4th Grade Material

Source: The authors (2024).

To move along the board, players advance their pieces according to the instructions provided by the command cards. Figure 6 shows the small boats used in the activity, while Figure 7 displays the stands used to hold the command cards.

Figure 6 – Boats Used in the 4th Grade Material

Source: The authors (2024).

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Figure 7 – Command Card Stand – 4th Grade

Source: The authors (2024).

The main objective of the proposed activity is to reach the treasure located at the center of the board by creating a sequence of steps using the available command cards. These cards can be selected according to the number of spaces to be moved (from 1 to 5 squares), depending on the student's chosen strategy. Additionally, there are cards that allow the player to turn right or left, changing the direction of the boat along the path. **Figure 8** illustrates the command cards provided to create the algorithms.

Figure 8 illustrates the command cards provided by the material for the creation of algorithms.

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Figure 8 – Command Cards – 4th Grade

Source: The authors (2024).

Throughout the board, images of coins and skulls are scattered along the paths. When a boat lands on a square containing a coin, the student must draw a good consequence card. Conversely, if the boat lands on a square with a skull, the student must draw a bad consequence card. These cards represent unexpected events that add complexity to the activity. Figure 9 shows examples of these consequence cards.

Figure 9 – Examples of Consequence Cards – 4th Grade

Source: The authors (2024).

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Once the cards are arranged on the stand, the student moves them one by one, reading the command and simultaneously moving the game piece according to the indicated direction. Thus, the participant must first analyze the situation, establish a strategy, select and arrange the cards, and only then "execute the algorithm" by following the sequence of commands.

The student who reaches the destination completes the challenge. Each round can include up to four participants if played individually; however, the teacher is free to organize group-based sessions, allowing for collaborative participation within a single round.

4.2 Material for the 5th Grade

The material designed for the 5th grade also consists of a path-based challenge and is titled *Rescue of the Coded Alien*. Its knowledge object is "algorithms with conditional selection," and the selected skill is EF05CO04, also described in Table 1.

Figure 10 shows the game pieces, which represent astronauts printed in different colors, and Figure 11 presents the board developed for this material. The stands used to hold the command cards have the same structure as those used in the 4th-grade material, previously shown in Figure 7.

Figure 10 – Astronauts Used in the 5th Grade Game

Source: The authors (2024).

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Figure 11 – Board for the 5th Grade Material

Source: The authors (2024).

The goal is to rescue an alien located at the center of a space station on the board. To achieve this, students must construct an algorithm that defines the path to be followed, using a logical sequence of steps created with the command cards provided during the game. The logic is similar to that of the 4th-grade material, but with a more complex storyline and commands that expand on conditional aspects and are consistent with the cognitive development level of 5th-grade students. Examples of command cards are shown in Figure 12.

Figure 12 – Examples of Command Cards – 5th Grade

Source: The authors (2024).

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Several whirlpools are scattered across the board. If an astronaut "falls" into one, the student must draw a card without knowing whether it will bring a good or bad consequence. Examples of these cards are illustrated in Figure 13.

Figure 13 – Examples of Consequence Cards – 5th Grade

Source: The authors (2024).

The main distinction between this material and the previous one lies in the greater variety and complexity of both the command and consequence cards, as well as the possibility of more simultaneous participants. The theme is also more age-appropriate for the students, as is the visual appeal of the board and its pieces.

The student whose astronaut reaches the spaceship to rescue the alien completes the objective. The material encourages the use of more conditional strategies and requires a higher level of abstraction and decomposition from the participants, in line with its increased complexity.

4.3 Analysis of the application of the teaching material

4.3.1 Application with the 4th Grade

The application of the material allowed for the collection of data regarding students' development during and after the activity. Initially, the analysis focused on two important

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aspects: the students' understanding of the proposed scenario and the level of difficulty of the material for their age group.

At the beginning of the activity, students showed some difficulty in understanding the dynamics related to directionality, since the algorithm to be constructed had to follow the perspective of the boat rather than that of the student controlling it. Therefore, greater intervention was initially required to help overcome issues related to laterality and spatial perspective, which were gradually resolved as the activity progressed.

Salgado *et al.* (2023) emphasize that, when working with computing concepts in the early years of schooling, it is important to introduce activities within contexts that are meaningful to children. Moreover, such activities should include elements of playfulness, motivation, and logical reasoning development. In this sense, the teacher's support is essential so that any initial confusion can be addressed and the activity can unfold smoothly.

> In light of the reality we face in many schools, unplugged computing emerges as a solution to attract children's attention to computing as a science. For these activities to be effective, they must be applied according to the age group, taking into account racial, gender, and sociocultural factors, and must aim to solve everyday problems in a playful way through computing fundamentals (Salgado *et al*., 2023, p. 81).

Once this initial "barrier" was overcome, the students quickly began to devise strategies, seeking to optimize their routes and selecting the most suitable command cards for the path they wanted their boats to follow. Consequently, new "levels" of challenges, not originally planned, had to be created to increase the complexity of the activity. These adjustments were later incorporated into the guide provided to teachers who would use the final version of the material.

Some of the new challenges included reaching the treasure and then returning to the starting point, or crossing the board from one side to the other. One detail observed was that when a student's boat landed on a square marked with a skull – requiring them to draw a bad consequence card – they sometimes became stuck in a loop and were unable

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to advance. To address this, a new rule was established: if a student landed on the same square for a second time, the boat would be "immune" to the consequence. This made the game more dynamic.

As planned, an interview was conducted at the end of the activity to gather feedback about both the material and the topic addressed. The children also proposed new ways to use the material.

When asked what they had learned during the activity, all students reported having learned something. Most of the responses highlighted the idea of "creating a path" or "finding a path" to solve the proposed problem. Student 2, referring to a route he had created, said: "We learned that each arrow is a card and you can move up to 5 spaces. You can do well or badly. When you get coins, it's good, and when you land on skulls, it's bad."

Vieira and Hai (2022) point out that, although abstraction is a key requirement for computing, other skills are also essential for information processing, with pattern recognition being one of the most important. In this sense, understanding the material's dynamics directly involves this ability, since the patterns established determine possible solutions to the problem. By recognizing these patterns, students begin to formulate hypotheses about strategies they can use to construct their proposed routes.

> Therefore, even before computational thinking emerged, the ability to recognize patterns was already crucial for our species. Activities that foster pattern recognition should be introduced as early as preschool, where children can encounter this skill through visual contexts and later advance to cognitive perceptions, allowing them to generalize, understand content, contexts, and problems, and build their own thinking across various levels of abstraction (Vieira; Hai, 2022, p. 4).

All students successfully completed the route, though at different paces. Overall, there was clear evidence of an initial understanding of the CT concept addressed in the material, particularly when students expressed that what they had done to make the boat move was an algorithm, after the concept had been explained.

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When asked what could be changed or added to the game, students offered several creative suggestions, such as: “There should be more obstacles, more skulls, and we shouldn’t be able to skip them” (Student 2); “Add different obstacles, have a timer, or include pirates on the board” (Student 3); “When you land on a skull, you should take two penalty cards with questions” (Student 4); “Have more paths, and when someone reaches the treasure first, others could battle to take it back” (Student 5); “When landing on a skull, instead of moving back 1 to 5 spaces, move back 2 to 7” (Student 2); and “There should be battle ships along the path” (Student 6).

Through these suggestions, students demonstrated reasoning and creativity, connecting their ideas to experiences from other games and activities. Ceratti and Nóbile (2023) emphasize that one of the objectives of CT is to promote knowledge construction and creativity. Therefore, even though this was their first contact with the proposed material, the students already showed signs of such cognitive engagement.

All students stated that they liked the pedagogical material and highlighted its visual elements as the most engaging features, mentioning “the coins” (Student 6), “the boats” (Student 2), “the treasure” (Student 4), and “the sharks” (Student 1). This underscores the importance of designing pedagogical materials appropriate to the intended educational level, using stories, shapes, colors, and characters that capture students’ interest and support the teaching and learning process.

When asked if they would like to continue using the material, all students responded positively. Invited to suggest how the teacher might use it, they proposed ideas such as: “In math class, the penalty cards could have questions like 2x2. If you got it wrong, you’d move back” (Student 5); “In history class, whoever won could tell the story of the game” (Student 3); “In science, the teacher could explain the sharks” (Student 6); “In math, we’d have to solve the problem mentally” (Student 2).

Ceratti and Nóbile (2023, p. 143) argue that “integrating computational thinking into various subjects through interdisciplinary approaches demonstrates its relevance across diverse contexts.” Thus, instead of being taught in isolation within Computer Science classes, CT can and should be incorporated into multiple disciplines. This was clearly

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reflected in the students' own responses, as they suggested new interdisciplinary uses for the material across different subjects.

In summary, the application of the material in the 4th grade revealed that, even though it was the students' first contact with the resource, they understood the proposed activity. Despite initial difficulties, they were able to assimilate the process and activate the core principles of CT, showing motivation and interest in continuing to use the material.

4.3.2 Application with the 5th Grade

The application of the material with 5th-grade students was characterized by a notable display of enthusiasm for the proposed activity. Although the terms *algorithm* and *computational thinking* were not explicitly mentioned during the initial presentation, it became evident that the children grasped these concepts through the practical execution of the activity.

As with the 4th-grade group, many students initially struggled to understand how the game worked, appearing confused, especially when attempting to plan their routes and select the correct cards to overcome obstacles. Wing (2016) emphasizes that, within the context of CT, it is necessary to think across multiple levels of abstraction, as it is not simply about solving a programming problem. "It is not just about the application developed with computers, but rather a way of reasoning for creating and solving complex problems" (Oliveira, Cambraia, and Hinterholz, 2021, p. 3). However, as the activity progressed, it became clear that students were learning to break problems into smaller parts, formulate strategies, and think in terms of action sequences, which are fundamental skills for understanding what algorithms are.

The issue of directionality and spatial perspective proved less challenging for this group, given that such concepts are more consolidated among students of this age. With a better-developed sense of direction, the students' main challenges were related to formulating strategies and overcoming their initial impatience to solve the problem at once. As they began applying decomposition and pattern recognition more effectively, their

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actions flowed more naturally into abstraction and the construction of the algorithm required for the route. Although the time for applying the material was limited, the students demonstrated early signs of abstraction, indicating the material's potential for fostering this skill, which, being longitudinal in nature, must be continuously stimulated.

> Abstraction is the process by which something is chosen as the object of attention – that is, a filtering process that ignores the characteristics of patterns we do not need in order to focus on those we do need, filtering specific details and creating representations or ideas about what we are trying to address or solve. Thus, when we form a general idea about something we wish to solve, we create a model, which is also the basic process through which we form thoughts that, in turn, arise from lived experiences and mediated communication (Vieira; Hai, 2022, p. 3).

Another aspect observed among the 5th-grade students was collaborative problem-solving. Contrary to what might be expected, students showed genuine commitment to helping their peers, both in understanding the problem and in finding better solutions. Each new entry point on the board led to a completely different route to rescue the alien, requiring new strategies. As a result, collective interaction was observed, even though each student controlled their own astronaut piece. Students also helped one another understand the consequence cards, which included concepts and vocabulary related to astronomy, with some words being unfamiliar to a few participants.

The heterogeneity of the class meant that students completed the task at different times. Those who finished first began to assist their peers, suggesting commands or commenting on their choices.

When discussing sociocultural aspects of CT in unplugged activities for elementary education, Salgado *et al.* (2023, p. 80) highlight that "children are driven by challenges, and collaborative activities are important tools for individual development and for understanding the benefits of working collectively toward a common goal." In this sense, the *BNCC Computação* itself encourages collective problem-solving. When addressing the algorithm as a knowledge object to be developed from 1st to 5th grade, it specifies the skill: "Construct and simulate algorithms, independently or collaboratively, that solve simple,

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everyday problems using sequences, conditional selections, and repetitions of instructions" (Brazil, 2022, p. 34, our emphasis).

After the rounds were completed, the interviews provided valuable insights into the students' perceptions of their experience. Similar to the 4th-grade students, all 5th-grade participants stated that they had learned from the material, successfully completed the challenge, and enjoyed the activity. Two students' comments illustrate this: "In life there are always obstacles" (Student 1) and "[I learned] that to reach the alien, you have to build a path using the cards" (Student 2). These statements reveal two perspectives—one practical, referring to the immediate task (Student 2), and another more philosophical (Student 1), who made an insightful analogy.

> Computational thinking will have become ingrained in everyone's life when words like algorithms and preconditions become part of everyday vocabulary; when nondeterminism and garbage collection take on the meanings used by computer scientists; and when trees are drawn upside down (Wing, 2016, p. 3).

All students said they would like to continue using the pedagogical material. When asked what could be changed or added, their suggestions focused on obstacles within the game, such as: "Add more obstacles to the board" (Student 4); "Include creatures moving around, like aliens with weapons" (Student 3); "You shouldn't be able to skip the whirlpools" (Student 1); "Instead of just drawing consequence cards in the whirlpools, you could be teleported to another part of the board, and a bad consequence could be that another player chooses which obstacle you must face" (Student 2).

Considering the knowledge object selected for this material—*algorithms with conditional selection*—these suggestions align closely with the concept, showing evidence of the internalization of conditional structures that are fundamental to most algorithms. The students' proposals for alternate paths demonstrate an understanding of flow and multiple execution possibilities through conditional logic (*if–else*), revealing that they perceived algorithms not merely as sequences but as flexible, adaptable systems.

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> Ideas, not artifacts. It is not only the software and hardware artifacts we produce that will be physically present everywhere and affect our lives all the time, but also the computational concepts we use to approach and solve problems, manage our daily lives, and communicate and interact with others. Computational thinking will become a reality when it is so essential to human endeavors that it ceases to exist as an explicit philosophy (Wing, 2016, p. 4-5).

At the end of the activity, all students expressed enthusiasm about continuing to use the material in future lessons. This interest clearly indicates that the practical, gamified, and playful approach was effective. The material not only stimulated logical reasoning and problem-solving skills but also sparked students' desire to create new scenarios. In describing the results of research with objectives similar to those of this study, Grebogy, Castilho, and Santos (2024) note that:

> The application of the unplugged activities developed to introduce computational and CT concepts to students in this age group revealed their engagement and interest in the proposal. This reinforces the relevance and necessity of teaching such concepts so that students can develop computing-related skills and competencies from the beginning of their educational journey (Grebogy; Castilho; Santos, 2024, p. 386).

When asked what most captured their attention about the material, all students mentioned the challenge itself, as illustrated by Student 1's comment: "[I liked] everything. I really enjoy challenges" (Student 1). When asked whether they would like their teacher to continue using the material, their responses reflected similar reasoning: "Yes, to work on our reasoning and bring more challenges" (Student 2).

In this regard, we reaffirm the statement by Salgado *et al.* (2023) that children are motivated by challenges, which foster their cognitive and personal development. Furthermore, it is worth recalling one of the elements encouraged by the BNCC (Brazil, 2022):

> Develop projects based on problems, challenges, and opportunities that are meaningful to the student's context or interests, individually and/or collaboratively, making use of Computing and its technologies, and applying computational concepts, techniques, and tools that make it possible to

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> automate processes across various fields of knowledge, grounded in ethical, democratic, sustainable, and inclusive principles, valuing the diversity of individuals and social groups (Brasil, 2022, p. 11).

Based on the data obtained from the application of both educational products, Table 5 presents a synthesis of indicators that help illustrate how the students articulated the pillars of CT during the activities.

Table 5 – Indicators of Computational Thinking Articulation in the Use of Materials

Pillar	Evidence
Decomposition	• When analyzing the board to identify the necessary commands for moving the piece and completing the path; • When determining the set of cards required for each round of command execution, treating each stage as a subproblem; • When understanding the steps needed to perform the task (analyze the path, select the route, execute each step, and verify the result).
Pattern Recognition	• When recognizing the relationship between the initial positioning of the pieces and the movements needed to successfully complete the route; • When understanding the relationship between the pieces and the number of movements required; • When establishing combinations between commands; • When analyzing the board and identifying connections between the starting point and possible advantages along the path; • When recognizing regularities on the board and possible relationships with available commands; • When anticipating steps and making possible generalizations.
Abstraction	• When focusing on the essential aspects of the problem; • When creating a mental model of the path before selecting the necessary commands; • When choosing command cards that could “shorten” the route by simplifying commands (e.g., cards that move more than one space at a time); • When developing strategies to avoid negative consequences distributed across the board.
Algorithms	• When systematizing the necessary commands for proper movement along the established path; • When debugging and correcting possible errors in the route; • When verbalizing the strategy used and the commands adopted during the path.

Source: The authors (2025).

In summary, the data obtained from the application of both materials confirm that the development of resources specifically designed for the early years of schooling can produce quick and consistent results in fostering computational thinking among children. Although the implementation was carried out on a limited scale, student engagement and

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acceptance were highly satisfactory. This suggests that a more continuous effort by teachers, integrating the material into different subjects and classroom content, would certainly contribute to more effective learning outcomes.

5 Final considerations

This study aimed to describe the results of a proposal focused on introducing CT through an unplugged teaching material specifically designed for 4th- and 5th-grade elementary school students. Through the application of the proposed materials, we sought to understand students' acceptance and initial performance when faced with an approach that was entirely new to them and still scarcely explored in Basic Education.

The main challenges encountered during the research were related to developing the material in a way that effectively incorporated the concept of CT. The results achieved demonstrate that the methodological approach adopted was successful in helping students understand the basic concepts of the selected learning objects.

It is true that a single, isolated action is not enough to develop all the expected skills. However, the students' engagement with the gamified challenges was evident, which is an essential element for teachers who wish to implement more continuous and longitudinal activities aligned with their teaching and learning objectives.

The application of the educational product showed that, in general, materials that respect students' age range and cognitive level, and that propose problem-solving activities—whether individually or collaboratively—are effective in promoting engagement and, consequently, the development of the skills outlined in the BNCC. It is important to emphasize that the material should be understood as a teaching aid, serving as a flexible tool that can be adapted to different classroom contexts. Nonetheless, further studies focused on learning outcomes are needed to deepen the understanding of the essential elements of a teaching material. Even so, the findings are relevant, as they offer promising directions for future work in this field.

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Regarding the pedagogical potential of the material, it is important to highlight that the proposal sought to introduce core concepts, while recognizing that continuous actions are necessary for the comprehensive and effective development of CT.

In summary, we conclude that this material holds significant potential and can be used across different educational institutions as a support tool for teachers, applicable not only in computing but also across other areas of knowledge. For this purpose, teacher training in the use of the material is essential to ensure its effective implementation in the classroom. In this regard, the materials developed have already served as instruments for new investigations, involving the analysis of interdisciplinary pedagogical possibilities by teachers through the use of the educational products described here.

We hope that the results presented in this study contribute meaningfully in this direction, opening paths toward a broader and more accessible understanding of the subject.

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