The Impact of Computational Thinking Pillars on the Development of BNCC Competencies through the Micro:bit

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Abstract. *This article examines how the pillars of computational thinking — decomposition, pattern recognition, abstraction, and algorithms — support the development of skills outlined in Brazil's National Common Curricular Base (BNCC) for grades 6th to 7th. The study analyzes the alignment between computational thinking pillars and BNCC competencies across various subjects of the final years of elementary school, and lays the groundwork for future integration of practical micro:bit projects to work with both, aiming to enhance students' cognitive, socio-emotional, and technological skills, while strengthening pedagogical practices in line with BNCC standards.*

1. Introduction

The advancement of technology in education has increasingly highlighted the need for students to develop skills that transcend traditional academic knowledge. In Brazil, the National Common Curricular Base (BNCC) outlines essential competencies that students must acquire, with a strong emphasis on critical thinking, problem-solving, and digital literacy. However, recent results from the Basic Education Development Index (IDEB) indicate that Brazilian students face significant challenges in achieving these competencies. The 2023 IDEB results, published by the National Institute of Studies and Educational Research Anísio Teixeira (INEP), show that Brazil fell short of the National Education Plan (PNE) targets for 2014-2024. The Final Years of Elementary School achieved 5.0, missing the target of 5.5. These results highlight a persistent decline in educational quality as students advance through the system, emphasizing the urgent need for effective interventions.

In response to these challenges, integrating Computational Thinking (CT) and Educational Robotics (ER) into the curriculum offers a promising approach. The CT concept has gained visibility by [Wing 2006] and has become a central focus in education for fostering essential skills. It is built on four core pillars: decomposition, which involves breaking down complex problems; pattern recognition, the process of identifying trends; abstraction, which emphasizes focusing on core ideas; and algorithm design, the creation of step-by-step solutions. These pillars, although well-known, are not the only existing pillars but are crucial in aligning with the competencies outlined in the BNCC. This makes CT a critical skill for students to develop as they prepare for an increasingly technological world.

ER, on the other hand, offers a dynamic and interactive approach to learning, grounded in established pedagogical theories as Piaget's constructivism which establish that learners build knowledge through experiences, and Papert's constructionism which extends this by emphasizing that students construct deeper understanding when engaged

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in creating tangible, meaningful objects [Sokolonski 2020]. Both theories align with Vygotsky's socio-cultural theory, which underscores the role of social interaction and collaboration in cognitive development [Chaidi et al. 2021]. Together, these frameworks foster increased student participation and motivation during the learning process. This, in turn, promotes a growth mindset by encouraging students to view challenges as opportunities for learning and personal development.

The research problem addressed in this paper is how to integrate the development of CT pillars with the acquisition of skills and competencies outlined in the BNCC. The structure of this paper begins by exploring the theoretical foundations of Computational Thinking (CT) and its alignment with BNCC competencies across various disciplines. Following this, we present a detailed mapping of BNCC skills to CT pillars for 6th and 7th grades, forming the basis of our analysis and showcasing how these principles can enhance educational practices in Brazil. Building on this foundation, we discuss our future approach, which includes developing micro:bit projects aligned with BNCC standards and organizing workshops for educators. These efforts aim to further integrate CT into the curriculum and support teachers in effectively implementing these innovative methodologies in their classrooms.

2. Related Works

The BNCC is a document that outlines the essential skills and competencies for Brazilian students, focusing on content knowledge, critical thinking, problem-solving, creativity, and digital literacy. Its goal is to prepare students for modern societal and job market challenges [BRASIL 2018].

Relating each CT pillar to the BNCC is crucial, as it aligns with the BNCC's emphasis on developing essential skills and competencies. CT is a process that involves various skills and techniques from computer science. Jeannette Wing, who popularized the term, defines CT as a way of thinking that allows people to tackle complex problems by breaking them down into smaller parts, recognizing patterns, abstracting general principles, and creating algorithms to automate solutions. According to [Wing 2006], CT is not just for computer scientists but is a fundamental skill that everyone should possess to navigate the modern world effectively. Integrating CT into education also prepares students for the future job market, where digital literacy and problem-solving skills are highly demanded.

Other researchers have expanded on Wing's work, exploring the various dimensions and applications of CT in educational contexts. [Grover and Pea 2013 apud Guarda and Pinto 2020], described CT as applying computer science tools and techniques to understand natural and artificial processes and systems. They also emphasized the importance of integrating CT into basic education, arguing that it enhances students' problem-solving skills and prepares them for the challenges of the digital age. Many other authors define CT as an essential skill for programmers and computer scientists. For example, [Anderson 2016 apud Guarda and Pinto 2020], considers CT as the way computer scientists think while solving problems. In many cases, CT is primarily seen as an approach to problem-solving. [Soleimani et al. 2016 apud Guarda and Pinto 2020], suggest that CT involves planning and designing systems using computer science concepts.

On the other hand, robotics has become an integral part of educational practices, offering a practical and engaging way to teach diverse subjects such as science, technology, engineering, arts, and mathematics (STEAM). Using this methodology to work with BNCC and CT will allow students to gain hands-on experiences that make abstract concepts tangible, promoting deeper understanding and retention. In this work, we consider the use of micro:bit[1] in classroom environments, which has been explored in various studies, demonstrating its effectiveness in increasing student engagement and learning outcomes.

The BBC micro:bit is a compact, programmable device designed to inspire students in digital creativity and innovation [BBC 2024]. As [Tohyama 2019] describes, it is a low-cost, user-friendly, versatile, and intuitive technology that empowers students to develop essential digital skills. Integrating the micro:bit into our project aligns well with its vision, providing a powerful tool to enhance learning while supporting our work in STEAM (Science, Technology, Engineering, Arts, and Mathematics) areas. [Tohyama 2019] explored collaborative programming learning using the micro:bit in a Japanese primary school. The study found that using the micro:bit in a collaborative learning environment, particularly through methods like the Jigsaw Method, helped students understand scientific concepts more deeply. The micro:bit served as an economical tool that alleviated teachers' anxiety about new technologies and allowed students to apply programming to real-world problems and experiments.

[Albuquerque et al. 2020] conducted research in a public school in northern Brazil, focusing on interdisciplinary and maker approaches using the micro:bit. Their study involved project-based learning (PBL) and the STEAM methodology, which integrates science, technology, engineering, arts, and mathematics. The research highlighted that students showed a strong preference for math and science when engaged in projects using the micro:bit. These activities not only increased student interest but also helped them relate school content to real-life applications, promoting a more dynamic and applied learning experience. Projects with the micro:bit, such as light control and temperature monitoring, facilitated a better understanding of theoretical concepts through practical application.

[Brandhofer 2021] evaluated a project in Austria aimed at implementing coding and robotics using the micro:bit in secondary schools. The project, "Learning to Think - Solving Problems," spanned from 2018 to 2020 and involved integrating the micro:bit into regular classroom activities to promote computational thinking and problem-solving skills. The study found that students' problem-solving skills significantly improved with prolonged and intensive exposure to the micro:bit. Additionally, the innovative and interactive class design increased student motivation and interest in programming and computational thinking, with girls, in particular, showing better performance in solving tasks.

Finally, [Beleti and Sforni 2023] provided a comprehensive analysis of the state of research on the development of computational thinking through experimental studies. Their systematic review revealed a strong emphasis on programming as the main method for fostering computational thinking, with the micro:bit being a popular tool in

[1] https://microbit.org/

these studies. The review highlighted the lack of standardized methodologies and the need for long-term experimental research to better understand the educational impact of these tools. Despite these challenges, consistent findings from various studies indicate that using robotics and tools like the micro:bit in education effectively enhances students' computational thinking skills and overall engagement in STEAM subjects.

3. Proposal

This work-in-progress seeks to establish a clear connection between CT pillars with the competencies outlined in the BNCC. We aim to methodically map these competencies to the core principles of CT: decomposition, pattern recognition, abstraction, and algorithm design. Our approach involves cataloging subjects from the BNCC for grades 6th to 7th — including Science, Math, Geography, History, Art, Physical Education, Portuguese, and English — into a detailed Excel spreadsheet. Each skill and competency will be analyzed and aligned with the relevant CT pillar. This process is based on a thorough examination of how each competency can be enhanced through the application of these principles. In the future, we plan to extend this mapping to cover the 8th and 9th grades, ensuring comprehensive coverage across all relevant subjects.

As a further step, we plan to validate this approach through a series of workshops aimed at engaging educators across multiple disciplines. These workshops will be structured in three phases. In the first phase, we will introduce the fundamentals of CT and explore its relationship with the BNCC competencies. This will be followed by collaborative discussions with the teachers to ensure that our categorization is meaningful and practical for real classroom settings, validating the proposed approach based on the feedback from educators of different areas. This step can also be important to highlight possible interdisciplinary relationships between Computation with other areas, providing arguments to reinforce the importance of learning Computation in basic education and how it can benefit other disciplines.

The second phase will introduce the micro:bit, a tool that facilitates hands-on learning, and guides participants through block-based programming, helping them understand how to apply CT principles through coding. In the final phase, educators will either develop their own micro:bit projects or work with pre-existing ones from the official BBC micro:bit website[2] related to their specific area and based on the collaborative discussion in the beginning of the workshop, gaining practical experience to bring back to their classrooms.

4. Results

A sample of the initial results of our research are presented in Table 1, which demonstrates the relationship between BNCC skills and each CT pillar for the Science discipline across different grade levels. By systematically cataloging and analyzing the verbs and action-oriented phrases within the BNCC skills, we have been able to correlate specific competencies with the appropriate CT pillars. For instance, verbs like "justify" in skills such as *(EF06CI07) Justify the role of the nervous system* are associated with the Decomposition pillar, as they require breaking down complex processes into understandable parts. Similarly, skills like *(EF06CI13) Select arguments*

[2] https://microbit.org/

and evidence can be related to the pillars of Abstraction and Algorithms due to the need to abstract the most important parts of the evidence to create algorithms that convincingly present those arguments.

Table 1. Relation between BNCC skills with each Computational Thinking Pillar for Science.

Grade	Subject	Skill	Pillar
6th	Separation of materials	(EF06CI03) Select the most appropriate methods for separating different heterogeneous systems based on the identification of material separation processes (such as the production of table salt, petroleum distillation, among others).	Decomposition, Algorithms
6th	Shape, structure and movements of the Earth	(EF06CI13) Select arguments and evidence that demonstrate the sphericity of the Earth	Abstraction, Algorithms
7th	History of fuels and machines	(EF07CI05) Discuss the use of different types of fuel and thermal machines over time, to evaluate advances, economic issues and socio-environmental problems caused by the production and use of these materials and machines.	Decomposition, Pattern Recognition
7th	Earth and Universe	(EF07CI12) Describe the natural mechanism of the greenhouse effect, its fundamental role in the development of life on Earth, discuss the human actions responsible for its artificial increase (burning of fossil fuels, deforestation, fires, etc.) and select proposals for reversing or controlling this situation.	Decomposition, Abstraction

See full table with years from 6th to 7th and all school subjects with their skills related to each one of the CT pillars at this link: https://rb.gy/qua4gd.

To further illustrate, in *(EF07CI05) Discuss the use of different types of fuel and thermal machines over time* are practiced the pillars of Decomposition and Pattern Recognition because students will decompose the different types of fuel and heat engines into their component parts to identify trends and consequences of the use of these resources over time. Finally, the skill *(EF07CI12) Describe the natural mechanism of the greenhouse effect* involves Decomposition and Abstraction, as students must focus on key elements while ignoring extraneous details and understand the human actions responsible for the artificial increase.

Table 2. Relation between BNCC skills with each Computational Thinking Pillar for Languages (Portuguese and English).

Discipline	Grade	Subject	Skill	Pillar
Portuguese	6th to 7th	Information curation	(EF67LP20) Conduct research, based on previously defined issues and clippings, using indicated and open sources.	Pattern recognition, Algorithms
Portuguese	6th to 7th	Text Production	(EF67LP31) Create poems composed of free verse and fixed forms (such as quatrains and sonnets), using visual, semantic, and sound resources, such as cadences, rhythms, and rhymes, as well as visual poems and video-poems, exploring the relationships between image and verbal text, the distribution of the graphic layout (visual poem), and other visual and sound resources.	Algorithms
English	6th	Hypotheses about the purpose of a text	(EF06LI07) Formulate hypotheses about the purpose of a text in English, based on its structure, textual organization and graphic clues.	Decomposition, Abstraction, Algorithms
English	7th	Construction of the overall meaning of the text	(EF07LI08) Relate the parts of a text (paragraphs) to construct its overall meaning.	Pattern recognition

See full table with years from 6th to 7th and all school subjects with their skills related to each one of the CT pillars at this link: https://rb.gy/qua4gd.

Table 2 focuses on the Languages discipline, specifically Portuguese and English, across grades 6th to 7th, showing how BNCC skills align with CT pillars. Unlike the Science table, where skills are tied to individual grades, the Language table occasionally spans multiple grades, as the BNCC organizes certain competencies across broader grade bands, such as 6th to 7th. For instance, the skill *(EF67LP20) Conduct research* requires the use of Pattern Recognition and Algorithms for identifying relevant information patterns and systematically organizing data to enhance research effectiveness. Similarly, the verb "create" in *(EF67LP31) Create poems* is associated with the Algorithms pillar, reflecting the structured narrative or poetic composition, following rules and patterns specific to the genres to effectively create poems.

In English, the verb "formulate" in *(EF06LI07) Formulate hypotheses* connects with the pillars of Decomposition, Abstraction, and Algorithms. Here, students break down the text into its structural elements, abstract essential details, and follow a logical sequence to develop hypotheses. Likewise, in the skill *(EF07LI08) Relate the parts of a text (paragraphs)*, the verb "relate" is connected to the pillar of Pattern Recognition as students are asked to identify and connect patterns across different paragraphs to understand the text's overall meaning.

This methodical approach of linking verbs to CT principles allows for a deeper understanding of how each CT pillar can enhance specific educational outcomes. By providing a clear and structured framework, our Excel spreadsheet serves as a valuable tool for educators, enabling them to effectively integrate CT into their teaching practices. This resource is designed to support teachers in creating more engaging and meaningful learning experiences, aligning with BNCC guidelines and fostering essential cognitive, socio-emotional, and technological skills in students.

The relationships established between the pillars of CT and the skills and competencies of the BNCC will guide the development of the pedagogical proposal for the Educational Robotics workshops, based on a practical and interdisciplinary approach for the development of the knowledge objects.

To illustrate further, in the context of the Portuguese subject, the skill *(EF67LP31) Create poems*, which focuses on creating poems using visual, semantic, and sound resources, can be effectively integrated with the Computational Thinking (CT) pillar of Algorithms through a micro:bit project called the "Poetry Generator"[3]. This project engages students in writing poems by generating random phrases (every time that the micro:bit is shaked) composed of adjectives, nouns, verbs, and adverbs. While programming this project, students are introduced to arrays, which store sets of words, and learn how algorithms are used to randomly select and combine elements from these arrays to form phrases. The iterative nature of generating phrases, refining selections, and combining them into coherent poetic forms exemplifies the use of algorithms in both creative and computational contexts.

5. Conclusion

The integration of CT pillars — decomposition, pattern recognition, abstraction, and algorithm design — within the framework of the BNCC demonstrates a powerful synergy between modern educational methodologies and national educational standards in Brazil. By aligning the competencies outlined in the BNCC with CT principles, particularly in subjects like Science, Math, and Geography, students can develop essential skills such as problem-solving, critical thinking, and digital literacy. The use of micro:bit projects, which offer practical, hands-on experiences, further enhances the application of these skills in a real-world context, making abstract concepts more tangible and accessible. This approach not only fosters deeper understanding of theoretical content but also promotes active engagement and motivation among students, especially in STEAM subjects.

[3] https://microbit.org/projects/make-it-code-it/poetry-generator/

Moreover, the alignment between CT pillars and BNCC competencies serves to address some of the existing educational challenges highlighted by the 2023 IDEB results, which indicate a need for more effective interventions in Brazil's educational system. By incorporating CT into the curriculum, educators can bridge gaps in students' cognitive and socio-emotional development, preparing them to navigate the complexities of an increasingly technological world. The findings suggest that computational thinking, when effectively integrated with BNCC standards through tools like the micro:bit, can play a significant role in improving educational outcomes and equipping students with the necessary competencies for the future.

5.1 Future Work

Building on the results of this mapping, future work will expand the connection between BNCC skills and CT pillars to the 8th and 9th years of Elementary School. This extension will ensure comprehensive coverage of competencies for these additional grades. Furthermore, we will focus on validating our approach through specialized workshops. These workshops will follow a structured approach: first, an introduction to CT fundamentals and their relationship with the BNCC, accompanied by collaborative discussions with educators to assess the practical application of these connections.

Next, participants will be introduced to the micro:bit, along with block-based programming, providing a hands-on introduction to coding. Finally, the third phase will involve project development, where teachers will either create their own micro:bit projects or use pre-existing ones from the official BBC micro:bit website. This three-phase workshop structure will not only prepare educators to integrate CT into their classrooms but also ensure that students benefit from practical, interdisciplinary learning experiences that align with BNCC competencies.

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