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Challenges and Transformations: The Role of Computational Thinking and the BNCC in High School Teacher Education

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Abstract:
Digital This study seeks to understand the challenges and transformations associated with the introduction of Computational Thinking (CP) and the National Common Curricular Base (BNCC) in high school teacher training. We used a qualitative, exploratory and descriptive approach, conducting an action research with 22 teachers from a professional school in Ceará. Data collection was conducted through a Google Forms form, semi-structured interviews, and the Free Association of Words Test (TALP), followed by content analysis as proposed by Bardin (2016). Four main categories of analysis emerged from the study, highlighting the perceived gap in teacher training that considers the application of CP, and the challenges it presents in high school teaching practice. Teachers face significant challenges in implementing the CP in their pedagogical practices, and the influence of the BNCC on this application is not clearly defined. Teacher education needs to go beyond mere adherence to predefined guidelines. The results have important implications for the formulation of teacher education policies and practices. The study suggests the need for more effective strategies to integrate CP into secondary school teacher education and indicates the need for further research in this area.

Keywords: *Computational Thinking. Common National Curricular Base (BNCC). Teacher Education. High School. Digital Education*

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I. Introduction

With the emergence of the digital age, we observe significant changes in various sectors of society, including education. One prominent change is the inclusion of Computational Thinking (CP) as an essential skill for the teaching and learning process. This skill has caused profound transformations in the way we teach. The National Common Core Curriculum (BNCC), aware of the importance of CP, highlights the need to integrate it into teaching strategies. With this, there is a need for adequate teacher training that allows for an effective application of this approach in the classroom.

The task of harmonizing the principles established by the Common National Curricular Base (BNCC) and the implementation of Computational Thinking (CP) in high school teacher education is an intricate and challenging undertaking. While the BNCC outlines the guidelines for pedagogical practice, it does not provide an explicit and easily applicable route for the effective inclusion of CP in the teacher education process. This scenario, therefore, requires a deeper study that transcends mere adherence to pre-established norms

. Even though we have seen progress in educational policies, a gap in teacher education that considers the application of Computational Thinking is still noticeable. This fact entails considerable challenges for pedagogical practice in high school. How do educators interpret and apply Computational Thinking in their classes? What is the influence of the BNCC in this process? These are questions that emerge from this situation and require a more careful analysis.

The aim of this study is to explore the challenges and transformations related to the introduction of the PC and the BNCC in high school teacher education. The dialogical approach of teachers' social representations is adopted to understand the obstacles and possible solutions that can guide the formulation of teacher training policies and practices.

This study adopts a descriptive-exploratory and qualitative approach, employing action research to capture the perceptions and representations of teachers from a professional school in Ceará. Data were collected via a Google Forms form and semi-structured interviews, supplemented by the Free Association of Words Test (TALP). The content analysis proposed by Bardin (2016) was used to analyze the data, resulting in the identification of four main categories of analysis.

The present research contributes to the field of teacher education, particularly in the high school context, by providing important insights into the introduction and implementation of the CP and the BNCC from the perspective of teachers.

The article is structured into five chapters: the introduction, which presents the theme and motivation for the study; the methodology, which details the approach and methods used; the theoretical framework, subdivided into "Computational Thinking and the BNCC" and "Teacher Training and Computational Thinking", which discusses the fundamental concepts that guide the study; "Results and Discussion", where the data collected are presented and interpreted; and finally, the final considerations, where the conclusions, implications, and suggestions for future research are presented.

II. Materials and methods

The The present research is characterized as a foundational study, aligned with the definition proposed by Gil (2019). A descriptive-exploratory approach was employed, which allowed for adaptable planning and emphasized the illustration of observed phenomena and their relationships with other variables. Our method was qualitative, recognizing the dynamic interplay between the real world and the individual, with a focus on the interpretation of phenomena and the assignment of meanings. Consequently, our analysis aimed to understand the perceptions and conceptualizations of the subjects regarding the theme under study.

This research utilized an action research methodology. As underscored by Gil (2019), action research is a form of investigation aiming to enhance the living conditions of those involved in the study through their active participation in the research process. This approach enables both researchers and participants to collaboratively analyze and interpret the data collected, merging research with practical actions in a particular field chosen by the researcher.

According to Gil (2019), action research facilitates the creation of scientific knowledge that is also socially pertinent, particularly in addressing complex and multifaceted problems that require inventive and practical solutions. Furthermore, this approach fosters an equitable relationship between researchers and participants, which encourages the development of a more inclusive and democratic body of knowledge.

The research sample included 22 teachers from a professional school under CREDE 07, located in the State of Ceará. To maintain participant confidentiality, alphanumeric identifiers were employed, such as P1, P2, P3, P4, etc.

The research design involved data collection through a Google Forms survey, which was administered from April 17 to 20, 2023. Participant selection was based on the relevance of their responses to the study of Computational Thinking.

The research method involved the Free Association of Words Test (TALP), a technique commonly used in educational research. According to Tavares and Alves (2011), TALP participants are prompted to offer the first word that comes to mind in response to a target word selected by the researcher. From the gathered responses, it is possible to perform statistical and content analyses to identify patterns and relationships between the words and concepts provided by the participants. This technique has proven useful in understanding individuals' mental representations concerning various educational topics, thereby enabling the development of more effective and suitable pedagogical strategies.

Semi-structured interviews, comprising four open-ended questions, were employed for this study. According to Gil (2019), this data collection technique is widely utilized in social research. It enables the interviewer to establish a set of questions while also accommodating the introduction of new themes and questions during the interview. Moreover, the semi-structured interview grants the interviewee the opportunity to voice their opinions and personal experiences, significantly contributing to the research's development.

For the analysis of the collected data, we utilized the elements of content analysis proposed by Bardin (2016). This approach includes a series of systematic and objective techniques for the description of message content, aiming to deduce knowledge about the production conditions. The content analysis process is composed of three phases: preliminary analysis, material exploration, and results treatment. This structure allows for a thorough and methodical analysis of the collected data and facilitates a reliable and consistent interpretation of the results.

During the data analysis phase of the collected survey responses, the fundamental stages of content analysis were undertaken as proposed by Bardin (2016). In the preliminary analysis phase, the data were selected, organized, and examined. Subsequently, during the material exploration phase, the data were coded and characterized to define the analysis categories, which included: (i) the definition of computational thinking and its application in education, (ii) the role of the BNCC in teacher training for the development of computational thinking, (iii) the contribution of Computational Thinking to the development of competencies and skills of high school students, and (iv) challenges encountered in the implementation of Computational Thinking in Education. Finally, during the results treatment phase, the data were analyzed and interpreted based on the theoretical principles, seeking to understand the perceptions and conceptualizations of the subjects about the features of Computational Thinking in teacher education. This comprehensive analysis provided us with insights that we believe will contribute significantly to the field of computational thinking in education.

III. Theoretical Reference

3.1 Computational Thinking and the BNCC

Computational thinking has emerged as a vital competency in education, particularly within our digital age. According to Papert (1980), computational thinking encompasses the ability to frame problems in such a way that they may be solved via algorithmic solutions, anchored in computer science principles and practices. Resnick (2007) adds that computational thinking involves skills such as decomposition, abstraction, pattern recognition, and algorithm creation.

Over time, computational thinking has evolved, becoming an essential skill within the technological era. Amid rapid digital transformation and a rising demand for computer science-related skills, computational thinking has gained recognition as an integral component of student education. Its incorporation into the Common National Curricular Base (BNCC) in Brazil underscores the significance of this competency. Torres et al. (2019) elucidate that the BNCC sets guidelines for the development of computational thinking, recognizing it as a transversal axis in the curriculum, to be addressed across various subjects.

For the effective integration of computational thinking into education, it is indispensable that teachers are equipped to cultivate this skill among their students. Wing (2006) emphasizes the necessity of teacher training for effective promotion of computational thinking. Teachers must develop knowledge and skills connected to the pillars of computational thinking and integrate them into their pedagogical practices.

The BNCC furnishes a framework for teaching computational thinking, providing guidance on how it can be embedded in various disciplines. In mathematics, for instance, it is possible to tackle the decomposition of complex problems into simpler steps and identify mathematical patterns (Wing, 2011). In science education, computational thinking can aid in simulating experiments and analyzing data (Grover & Pea, 2013). Moreover, in language classes, algorithms can facilitate programming skills and interactive story creation (Resnick et al., 2009).

There are numerous practical examples that illustrate how computational thinking is being applied in education. For instance, the "Scratch" program, developed by MIT's Lifelong Kindergarten research group, enables students to craft interactive stories and games through visual programming blocks (Resnick et al., 2009). Another instance is the "Robotics Academy" project, which employs educational robotics to introduce programming concepts and computational thinking to students (Papert, 1980).

In summary, computational thinking occupies a critical role in student education in the digital age. Its inclusion in the BNCC underscores its importance for the development of crucial competencies for the 21st century and calls attention to the need for its integration into various subject teachings. The pillars of computational thinking, including decomposition, pattern recognition, abstraction, and algorithm creation, endow students with fundamental skills necessary for addressing today's challenges (Papert, 1980; Resnick, 2007).

The integration of computational thinking into pedagogical practice necessitates the training of teachers to develop this competency among their students. Teacher training should encompass the acquisition of theoretical and practical knowledge about computational thinking and pedagogical strategies for integrating it across various subjects (Wing, 2006).

The BNCC plays a pivotal role in offering clear guidelines on how computational thinking can be applied in an educational context. It accentuates the importance of fostering skills related to computational thinking at all stages of Basic Education, guaranteeing the formation of students who are better equipped for contemporary society's challenges (Brazil, 2018).

In conclusion, computational thinking is vital in student education, preparing them for a world under constant transformation. Its inclusion in the BNCC acknowledges its significance and reinforces the necessity of its promotion within the educational environment. Teachers play a key role in incorporating computational thinking into the curriculum, and teacher training should prioritize the development of skills and competencies associated with this domain. By embracing computational thinking, education becomes more inclusive, dynamic, and aligned with the needs of the 21st century. This adjustment equips students with skills that allow them to navigate the complexities of our digital society effectively, ultimately fostering a learning environment that cultivates future-ready learners. As we progress in this digital age, the importance of computational thinking, along with its promotion and integration into education, will only continue to grow.

3.2 Teacher education and computational thinking

Teacher education is fundamental for the effective incorporation of computational thinking in education. Training educators in this domain is crucial in preparing them to meet the challenges of today's world and in promoting the development of skills and competencies related to computational thinking among students. In this context, the contribution of teacher education to the integration of computational thinking in pedagogical practice becomes particularly pertinent (Freire, 2016; Mishra & Koehler, 2006).

With time, teacher education has evolved to align with the demands of a society that is increasingly defined by digital technologies. The adoption of computational thinking as a pedagogical approach is emerging as a strategy to prepare students for the challenges of the 21st century (Sentance & Csizmadia, 2017). Computational thinking is a skill set that encompasses problem-solving, logical reasoning, creativity, and the capability to work with technology (Grover & Pea, 2013).

The Common National Curriculum Base (BNCC) in Brazil acknowledges the importance of computational thinking in students' education and incorporates it as a competency to be developed throughout Basic Education (Brazil, 2018). This emphasizes the need for teachers to be equipped to teach this skill within their respective subjects.

For computational thinking to be effectively integrated into teacher education, the development of specific skills and knowledge is required. Teachers must acquire a comprehensive understanding of the principles and concepts of computational thinking and its applications in various educational contexts (Wing, 2006). Additionally, they should be capable of designing activities and projects that encourage computational thinking among students (Angeli & Valanides, 2009).

Teacher education plays a crucial role in this process. Continuing education programs can provide teachers with opportunities to update their knowledge on computational thinking and gain pedagogical strategies for its implementation (Denner et al., 2019). Involvement in communities of practice and the exchange of experiences among teachers are also significant factors for professional development in this area (Guzdial & Forte, 2005).

There exist numerous examples of teacher education programs that integrate computational thinking across different educational contexts. For instance, teacher training can encompass hands-on activities such as creating digital games, programming electronic devices, and solving problems using computational tools (Brennan & Resnick, 2012; Morelli et al., 2016).

Such practical approaches enable teachers to experience computational thinking within their own pedagogical practice, understanding its challenges and potential (Freire et al., 2020). Moreover, pedagogical practices that involve authentic problem-solving, student collaboration, and the exploration of different technologies serve as tangible examples of how computational thinking can be incorporated into teacher education (Grover & Pea, 2013; Kafai & Burke, 2014).

Educating teachers in computational thinking is crucial in preparing educators to promote the development of this skill among students. Incorporating computational thinking in teacher education contributes to more inclusive education, in line with the demands of contemporary society. Active involvement in continuing education programs, ongoing knowledge updates, and the exchange of experiences among teachers are key factors in enhancing educators' capacity to teach computational thinking. This pedagogical approach opens the door to developing essential skills such as problem-solving, logical reasoning, and creativity, preparing students for an ever-evolving world (Barr & Stephenson, 2011; Denner et al., 2019).

IV. Result and Discussion

In this section, we present the results of the analysis of the participants' responses to the free word association test, conducted as part of this study. The objective of this step was to identify the central nuclei that emerged from the words evoked in relation to the inductive term "computational thinking". This analysis allowed us to identify the most relevant perceptions and conceptions of computational thinking, based on the frequency of the words evoked, as shown in Table 2.

Table 2: Frequency of evoked words

Words	Frequency
Unknown to me	3
Technology	3
Logic	3

Creativity	2
A learning methodology	2
Technical Thinking	1
Dynamic	1
Creative	1
Efficient Thinking	1
Resolutive Thinking	1
Effective Thinking	1

Compiled by the authors (2023)

After further analysis, I identified the three major central cores of the evoked social representations for "COMPUTATIONAL THINKING IS...":

i) Technology: Technology is a dominant central core in the associations made with computational thinking. It is often mentioned as a key characteristic, being linked to the use of computers, machines, and the technological context in general. This indicates that people relate computational thinking to the use and application of technological tools.

ii) Logic: The core of logic is closely associated with computational thinking. Logic is repeatedly mentioned as a way to approach problems and find rational and efficient solutions. This association highlights the importance of logical and systematic reasoning in the context of computational thinking.

iii) Creativity: Creativity is another important core associated with computational thinking. While logic is fundamental, creativity is valued as a complementary ability that allows one to find innovative solutions to complex problems. This association indicates that computational thinking is not only based on formulas and algorithms, but also involves the ability to think creatively and flexibly.

In analyzing the participants' responses, we observed that the most significant central cores are related to technology, logic, and creativity. The frequent presence of the word "technology" highlights the intrinsic connection between computational thinking and the use of technological tools and systems. This indicates that participants perceive computational thinking as an approach that depends on the technological context.

Moreover, logic is repeatedly mentioned as a central core. Participants associate computational thinking with a rational and systematic approach to problem solving. This emphasis on logic suggests that participants recognize the importance of following logical principles and algorithms in computational thinking.

Another relevant central core is creativity. Participants recognize that computational thinking is not just limited to following formulas and algorithms, but also involves the ability to think creatively and flexibly. This association underscores the importance of finding innovative and adaptable solutions in the context of computational thinking.

4.1 Analysis of Semi-Structured Interview

For you, what is computational thinking and how can it be applied in education?

Urged to discuss computational thinking and its application in education, several teachers' responses were analyzed using Bardin's (2016) content analysis approach. From this analysis, it was possible to identify the following significant clusters related to computational thinking:

i) Effective and strategic problem solving: Teachers emphasize the importance of computational thinking as a skill to solve problems effectively and strategically. They emphasize the ability to break down complex situations into smaller parts, think logically and sequentially, and use analysis and algorithms to address educational challenges. This approach aims to achieve efficient and creative solutions (P1, P4, P8, P16, P22).

ii) Application in education and teaching methodologies: Teachers recognize the importance of computational thinking in education and teaching practices. They mention that computational thinking can fill gaps, assist in building a good education, and complement active methodologies in the classroom. Teachers emphasize the need to use computational thinking in innovative activities, combining technology and knowledge. Moreover, they emphasize the transversality of computational thinking in all subjects and its application as a teaching and learning methodology that broadens students' view of problems and enables them to solve them (P2, P3, P6, P11, P15, P18, P19, P20, P21).

iii) Pattern recognition: One of the aspects mentioned by teachers is pattern recognition as part of computational thinking. This ability to identify regularities and relationships between elements is highlighted as an important skill in the context of computational thinking (P9).

About this issue, we highlight the speeches of the teachers:

> It is the ability to solve problems by applying the technique of breaking down complex situations into smaller parts (P4).

> Computational thinking is based on problem solving through the use of analysis and algorithms (P22).
> Pattern Recognition (P9).
> New technological tools in favor of education, which can be used from interdisciplinarity and new learning strategies (P18).
> Applying across the board in all school subjects (P21).

Analysis of the teachers' responses showed that computational thinking was recognized as an essential skill for effective and strategic problem solving. Teachers emphasize decomposing complex situations, using analysis and algorithms, and recognizing patterns as central elements of computational thinking. Furthermore, they highlight the application of computational thinking in education, emphasizing its relevance across disciplines, active approaches, and the use of technology. The perceptions of these teachers demonstrate the importance of promoting computational thinking as an integrative and preparatory educational approach for today's challenges.

What is the role of the National Common Core Curriculum (BNCC) in teacher education for the development of computational thinking?

To perform the analysis of the teachers' responses regarding the role of the National Common Curricular Base (BNCC) in teacher training for the development of computational thinking, we will use Bardin's (2016) content analysis approach. From this analysis, we can identify the following categories:

i) Guidance and direction: Teachers emphasize that the BNCC has the role of guiding, directing and assisting with themes and teaching methodologies. It serves as a guiding document for pedagogical work, providing guidance and guidelines for teaching practice (P2, P5, P7, P9, P13, P20).

ii) Updating and training of teachers: The answers point out that the BNCC requires updating and training of teachers so that they are qualified to deal with new educational approaches and perspectives, including computational thinking. Teachers emphasize the importance of continuing education and the search for updated instruction and practices (P4, P11, P12, P15, P17, P18).

iii) Democratization of knowledge: teachers emphasize that the BNCC plays a key role in democratizing knowledge related to computational thinking. It encourages the discussion, appropriation and replication of this knowledge in educational institutions, promoting its inclusion as priority content in the training of teachers and students (P7, P16, P22).

iv) Integration of technologies: The BNCC is mentioned as a document that guides on the use of technologies in education. However, some teachers point out the need to deepen this aspect, in order to adapt to contemporary demands and ensure continuous technological training (P6, P14, P19).

About this issue we highlight the speeches of the teachers:

> It is important because it helps clarify the necessary situations in teacher training (P5)
> Provide guidance on the guidelines and how new technologies can be executed (P20)
> The Base requires updating the teacher so that he/she becomes capable of exercising his/her function in face of the new approaches and perspectives (P4)
> Continuing education is fundamental for us to have good teachers continuously (P15)
> Encourage computational development among teachers and students (P22)
> Provide knowledge and work on skills in this aspect (P14)

The analysis of the teachers' answers reveals that the National Common Core Curriculum (BNCC) plays an important role in teacher education for the development of computational thinking. The BNCC guides and directs pedagogical practices, stimulates the updating of teachers and seeks to democratize knowledge. However, it is necessary to improve the approach to technologies and ensure continuous technological training.

How can computational thinking contribute to the development of skills and abilities in high school students?

By analyzing the participants' responses regarding the contribution of computational thinking to the development of skills and abilities in high school students, using Bardin's (2016) content analysis approach, we can identify the following categories:

i) Problem solving and critical thinking: Participants highlighted that computational thinking assists students in developing problem solving skills, stimulating critical and creative thinking. Through innovative teaching and activities that promote creativity and critical thinking, students are empowered to recognize and solve problems effectively (P3, P6, P10, P11).

ii) Cognitive development: Computational thinking is seen as a process that occurs in stages, involving mental operations from the simplest to the most complex. It contributes to students' cognitive development, following Bloom's Taxonomy, which covers different levels of knowledge, comprehension, application, analysis, synthesis, and evaluation (P7).

iii) Organization, decision-making and logical **reasoning**: Participants mentioned that computational thinking promotes the organization of activities, the identification of an order of execution to solve problems and the development of logical reasoning. In addition, it helps in decision making, the development of critical sense, and standardization and identification of characteristics that contribute to the improvement of teaching (P8, P10, P17, P19, P20).

iv) Interdisciplinary integration and use of technologies: Computational thinking is considered important to include new learning strategies in an interdisciplinary way, using educational applications and gamified practices. It also facilitates understanding and performing everyday actions, as well as analyzing and researching digital sources in different areas of knowledge (P9, P11, P14, P22).

> Getting students to use their critical and creative thinking, advancing through innovative teaching (P3)
> Broadening the thoughts, ideas, and creativity for problem solving. This can be achieved through a gamified practice in the classroom (P11)
> Computational thinking can help in the cognitive development of students, considering that this process happens in stages that involve mental operations from the simplest to the most complex level, as categorized in Bloom's Taxonomy (knowledge, understanding, application, analysis, synthesis and evaluation) (P7)
> Students will be able to perform activity organization, identify and define an order of execution to solve a problem (P8)
> Decomposition involves analytical and problem identification skills. (...) Therefore, computational thinking has an impact on all areas of knowledge. (P22)

These categories indicate that computational thinking has the potential to contribute to the development of skills and abilities in high school students. It promotes problem solving, critical thinking, cognitive development, organization, decision making, and logical reasoning. In addition, it allows for interdisciplinary integration and the use of technology as an educational resource.

What are the main challenges you have faced in implementing computational thinking in education?

By analyzing the participants' responses on the main challenges faced in implementing computational thinking in education, using Bardin's (2016) content analysis approach, we can identify the following categories:

i) Training and time: Participants mentioned lack of adequate training and lack of time as significant challenges in implementing computational thinking in education (P1).

ii) Adaptation and change of habits: The adaptation and maturation needed to implement computational thinking are challenges highlighted by the participants. They highlight the difficulty of breaking the tradition of traditional teaching and dealing with new approaches and practices (P2, P4).

iii) Resources and technology: The lack of sufficient resources and the difficulty in dealing with technology were mentioned as challenges in implementing computational thinking. Participants point to the need for greater apparatus and the lack of knowledge about appropriate platforms and teaching materials (P3, P5, P11, P16, P18, P19, P20).

iv) Changing student perspectives and interests: Participants highlight the difficulty in dealing with students' lack of understanding and interest. In addition, they emphasize the importance of changing students' perspective towards learning and adopting new technologies (P6, P8, P17).

v) Infrastructure and support: The lack of school infrastructure, access to adequate equipment, availability of support materials, and support from school managers are mentioned as challenges in implementing computational thinking (P10, P12, P14, P15, P22).

About this issue, we highlight the speeches of the teachers:

> The lack of training and the lack of time (P1)
> The resources are still not enough, although, we can take other active methods, but it still requires a greater apparatus (P3)
> [...] We were born in a time when teaching was traditional, we only solved exercises related to the content. Therefore, we carry with us this tradition, which is not easy to break. It requires resilience, study, training, and courage to deal with the new (P4)
> [...] Professionals who have difficulty adapting to the contemporary needs of education, who have not realized the importance of technology as a partner in the educational process. It is not easy to change, but increasingly one must adapt to this reality (P6)
> Teacher training, communication between teachers, school infrastructure, and the support of school managers (P22)

The implementation of computational thinking in education faces challenges such as lack of training, scarcity of technological resources, change of habits, and lack of student interest. It is necessary to invest in teacher training, adequate infrastructure, and awareness of the importance of computational thinking. Overcoming these challenges will require the joint efforts of teachers, administrators, and educational institutions.

V. Conclusion

The analysis of the participants' responses allowed us to identify the main challenges in implementing computational thinking in education, including lack of training, scarcity of technological resources, change of habits, and lack of student interest.

The research sought to understand the challenges faced in implementing computational thinking in education. The results obtained provided valuable insights into the difficulties faced by teachers in this process.

The implications of the results are relevant for educators, managers, and educational policy makers. The information obtained can help in identifying areas that need greater attention and investment to promote the successful implementation of computational thinking in education.

A limitation of this study is its exploratory nature and the use of a specific sample of participants. Future research may broaden the scope by including a more diverse sample of teachers and exploring specific strategies to overcome the identified challenges.

This study contributes to understanding the challenges in implementing computational thinking in education, highlighting the importance of training, adequate technological resources, and changing students' perspectives.

The findings of this study can be applied in developing teacher training programs, creating adequate educational infrastructure, and implementing pedagogical strategies that promote computational thinking.

Therefore, this study highlighted the challenges faced in implementing computational thinking in education and highlighted the importance of overcoming these obstacles. Understanding these challenges can direct educational actions and policies that promote the development of computational thinking, empowering students for the challenges of the digital world..

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