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Article

Pedagogical paths for the integration of computational thinking in professional education

Caminhos pedagógicos para a integração do pensamento computacional na educação profissional

Aportes del pensamiento computacional en la formación continua de docentes de educación profesional y tecnológica

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ABSTRACT

Computational thinking goes beyond the idea of programming a computer and is centered around the idea of how humans, not computers, think. Considering the need to integrate this theme into education, we sought to promote the development of computational thinking in the practice of professional and technological education teachers. For this, application-research was used as a research method, and an online course was carried out with the participation of five teachers working in the integrated high school of the Federal Institute of Bahia and monitoring by a pedagogue. For data analysis, qualitative content analysis was used on the vocabulary, the field diary and the descriptive memorials. The results show pedagogical paths for the integration of computational thinking by teachers.

Keywords: Professional and Technological Education. Computational Thinking. Continuing Education. Research-Application.

RESUMO

O pensamento computacional vai além da ideia de programar um computador e está centrado na ideia de como os humanos, e não computadores, pensam. Considerando-se a necessidade da integração deste tema à educação, buscou-se promover o desenvolvimento do pensamento computacional na *práxis* dos docentes da educação profissional e tecnológica. Para isso, fez-se uso da pesquisa-aplicação como método de pesquisa, e por meio dela foi realizado um curso *on-line* com a participação de cinco docentes atuantes no ensino médio integrado do Instituto Federal Baiano, além do acompanhamento de uma pedagoga. Para a análise dos dados, utilizaram-se a análise de conteúdo qualitativa sobre o questionário diagnóstico, o diário de campo e os memoriais descritivos. Os resultados mostram caminhos pedagógicos para a integração do pensamento computacional pelos docentes.

Palavras-chave: Educação Profissional e Tecnológica. Pensamento Computacional. Formação Continuada. Pesquisa-Aplicação.

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RESUMEN

El pensamiento computacional va más allá de la idea de programar una computadora y se centra en la idea de cómo piensan los humanos, no las computadoras. Considerando la necesidad de integrar este tema en la Educación, buscamos promover el desarrollo del Pensamiento Computacional en la práctica de los profesores de Educación Profesional y Tecnológica. Para ello, se utilizó como método de investigación la investigación-aplicación a través de la cual se realizó un curso en línea con la participación de cinco profesores que actúan en la Enseñanza Media Integrada del Instituto Federal de Bahía, además del acompañamiento de un pedagogo. Para el análisis de los datos, se utilizó el análisis de contenido cualitativo del vocabulario, el diario de campo y las memorias descriptivas. Los resultados muestran caminos pedagógicos para la integración del Pensamiento Computacional por parte de los docentes.

Palabras clave: Educación Profesional y Tecnológica. Pensamiento Computacional. Formación Continua. Investigación-Aplicación.

INTRODUCTION

In the educational field, particularly in Brazil, the use of digital information and communication technologies (DICT) in public schools is largely restricted to activities such as internet research, word processing, slide presentations, spreadsheet management, and the use of similar software.

Several countries, including Germany, Argentina, Estonia, the United States, Finland, and France, have moved beyond merely implementing computer labs in schools and have taken more substantial steps by incorporating computer science education into the curriculum from elementary school onward (Brackmann, 2017). The objective is to go beyond traditional computer science classes, where instruction is limited to teaching students how to use digital tools. This integration has occurred at different times in each country, and, due to variations in educational systems, no standardized approach or consensus exists regarding its implementation.

In 2018, the Brazilian education system underwent a reform that led to the development of the National Common Curricular Base (*Base Nacional Comum Curricular* — BNCC), a normative document that guides the curriculum and pedagogical activities across the stages and modalities of Brazilian basic education (Brasil, 2018). Regarding digital technologies and computing, the document emphasizes the importance of aligning the ten general competencies for student learning and development with the three axes of computing (computational thinking — CT, the digital world, and digital culture); however, the discussion on CT is limited to the field of mathematics and related technologies, making it the sole discipline in the curriculum responsible for implementing this integration.

For the benefits of computing to be effectively reflected in society, curriculum discussions must be integrated across different fields of knowledge, as no single discipline should be prioritized in an individual’s formative process. In this context, professional education, guided by the concept of an integrated curriculum, aims to overcome the division between technical and general education disciplines. This approach emphasizes the collective construction of the curriculum, structured around problem-based learning, in which curricular components are interwoven (Ramos, 2014).

When professional and technological education (PTE) is considered within the scope of research, a noticeable limitation emerges regarding the availability of specific educational resources, as well as the scarcity of publications that directly address CT within the professional practice of these educators (Almeida *et al*., 2021). In this context, researching CT in PTE is particularly relevant, as it enables the development of pedagogical approaches that expand educators' perspectives by bridging computational thinking with holistic human development.

Given the limited availability of educational resources, the ineffectiveness of public policies concerning teachers' continuing education, and the challenges associated with implementing an integrated curriculum, the following question arises: What are the possibilities for incorporating CT into the teaching practices of educators in integrated secondary education (*ensino médio integrado* — EMI) within PTE? To address this question, the general objective of this research was to promote the use of CT among teachers in EMI. To achieve this, three specific objectives were established: to investigate how discussions on CT have been taking place in PTE, based on publications available on the Portal of the Special Commission for Informatics in Education (*Comissão Especial de Informática na Educação* — CEIE); to develop strategies and tools that enhance the teaching and learning process by integrating CT; and to design pedagogical approaches for the development of a course on CT tailored for PTE teachers.

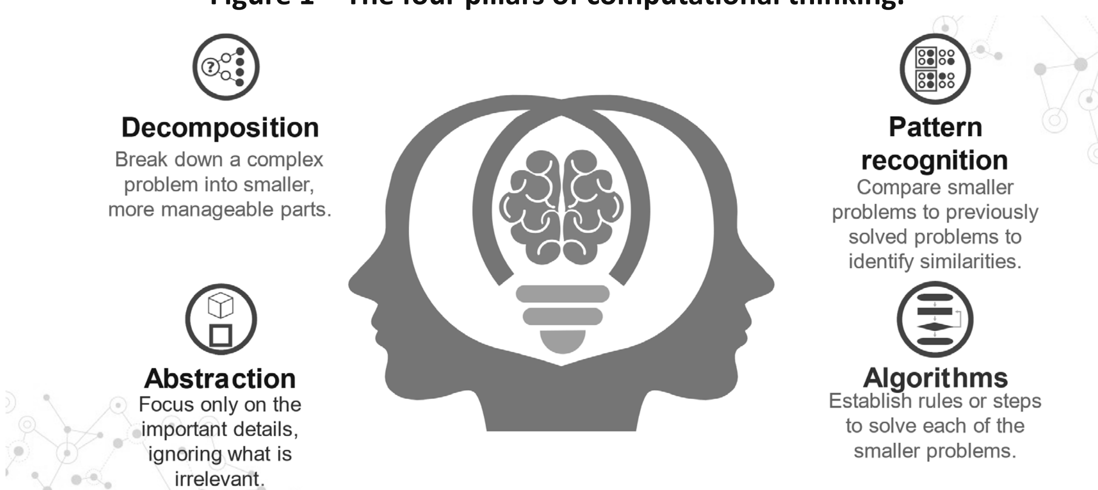
To achieve these objectives, applied research was conducted (Plomp, 2018), with a focus on education, to guide the planning, implementation, and evaluation of a course structured in two cycles, designed to address the pedagogical needs identified by the participating teachers. For the analysis and discussion of the results, content analysis was employed (Bardin, 2016) to infer and interpret the data generated.

COMPUTATIONAL THINKING

The term CT gained prominence in academic circles in 2006, following the publication of an article by researcher Jeannette M. Wing, who emphasized that this type of thinking should not be exclusive to computing professionals. Instead, she argued that, alongside reading, writing, and arithmetic, CT should be incorporated as an essential analytical skill for all children (Wing, 2006).

CT can be defined as the ability to solve problems in a methodical and systematic manner. It is commonly structured around four pillars (Brackmann, 2017): decomposition, pattern recognition, abstraction, and algorithms, as illustrated in Figure 1.

Figure 1 – The four pillars of computational thinking.



Source: the authors (2021).

According to studies conducted by Brackmann (2017), many countries have already incorporated the teaching of computer science into basic education, including Germany, Argentina, Australia, South Korea, Scotland, and the United States. In addition to these, numerous other countries have introduced computer science courses in the curriculum of the early grades of basic education. In Brazil, however, despite the approval of the BNCC in December 2018, which regulates how learning will occur throughout the stages and modalities of basic education, the teaching of computer science concepts was not integrated into the curriculum. This, in our view, indicates a disconnect in the proposed approach to computer science and its broader context in the socio-educational progress we have experienced.

In this new curricular framework, CT is positioned within the field of mathematics and its technologies (Brasil, 2018). However, given its transversal nature, this skill should not be confined to a single area of knowledge, as computing is a discipline that spans across other scientific fields (SBC, 2019). Therefore, it is crucial to recognize that, despite its close relationship with the exact sciences, CT should be approached and discussed in an interdisciplinary manner.

CT can be integrated into education in various ways, as outlined by Valente (2016), including the following possibilities: unplugged computing, which involves activities that do not require digital technologies; Scratch programming, a visual approach to computer programming that uses the concept of dragging and fitting blocks rather than typing text; pedagogical robotics, which involves programming robots to build, modify, and automate programmable devices; the creation of digital narratives, using computer programs to craft stories with images, sounds, audios, videos, and animations; game creation, using software to develop personalized content; and the use of simulations, which employ software to help students understand real-world situations through projections.

There are, therefore, numerous possibilities for integrating CT into teachers' classrooms. However, for this integration to be effective, Yadav, Stephenson, and Hong (2017, p. 59) emphasize that "teachers need to master the content of their subjects and understand how Computational Thinking concepts relate to their students' learning in the classroom." Consequently, a collaboration between computer science teachers and educators from other disciplines is essential to enable teachers to incorporate CT into their lessons.

Therefore, it is not sufficient to merely adopt a new approach in the classroom. Teachers must have a deep understanding of the subject matter, the concepts related to it, and determine how these relationships will be effectively integrated into the teaching process.

COMPUTATIONAL THINKING IN PROFESSIONAL AND TECHNOLOGICAL EDUCATION

PTE aims to educate individuals for more than just the job market. It is more than just training and qualifying students with specific technical training to meet the demands of a productive society.

In Brazil, PTE has been shaped by a structural duality between manual labor and intellectual labor. During the colonial period, manual tasks requiring significant physical effort were carried out by enslaved Black and Indigenous people, who were forced to serve the colonizers. Meanwhile, the Jesuits were responsible for educating the children of the colonizers, providing them with a more humanistic and intellectual education (Oliveira and Caires, 2016). As a result, racial and social prejudices were established against those whose work primarily involved physical labor.

To overcome the market-oriented perspective of Brazilian professional education, authors such as Saviani (2003), Frigotto, Ramos, and Ciavatta (2005), and Machado (2014), among others, explore the concepts of polytechnic education and technological education within the context of secondary and professional education. The implementation of EMI thus represented an opportunity to improve conditions for the development of technological education, grounded in comprehensive, civic, and critical human formation, while addressing the structural duality that has long characterized Brazilian education (Oliveira and Caires, 2016, p. 142).

A more thorough discussion of CT in PTE is essential, as vocational education represents a field of contention between social classes due to its connection with the world of work. As an educational approach that seeks to shape individuals across the dimensions of science, culture, work, and technology, PTE fosters a critical worldview aimed at promoting human emancipation.

In this context, it is important to clarify that the concept of technology presented in this text should be understood as the epistemology of technique, "the term used to describe the mediation performed by human actions, either directly or through instruments, in achieving the goals conceived by humans to overcome the resistance of nature" (Silva, 2013, p. 843). This perspective recognizes that technology encompasses the entire historical production of humanity, including the discovery of fire, the invention of the wheel and writing, and is not limited to the digital revolution phenomena such as biotechnology, nanotechnology, and other digital technologies (SBC, 2019).

However, many PTE teachers and students fail to grasp the concept of technique in its broadest sense. They often use the term "technology" as jargon for "innovative" and futuristic productions, thereby reducing its meaning. This narrow view overlooks the intentional manipulation of the concepts of technique and technology by the ruling class, which serves to advance political and social interests.

It is important to emphasize these definitions to ensure that there is no misunderstanding, and that electronic and digital productions are not the sole considerations when defining technology.

Based on these concepts, and with an emphasis on the educational aspect, CT enables both teachers and students to undergo a cognitive shift in the way technology is produced. It not only involves creating and cataloging solutions for various existing problems but also contributes to reflecting on actions, self-awareness, and interpersonal relationships, resonating within their broader formative processes.

From this transdisciplinary perspective, Seymour Papert explores the impact of computers on the educational environment in his work *The Children's Machine: Rethinking School in the Age of the Computer*:

> Since the creation of the printing press, there has been no greater impetus to encourage technical learning. However, there is another side: paradoxically, the same technology has the potential to de-technologize learning. If this were to happen, I would consider it a much greater change than the emergence, on each desk, of a computer programmed to guide students through the steps of the same old curriculum. However, it is not necessary to quibble about which change has the farthest reach. What is necessary is to recognize that the big question in the future of Education is whether technology will strengthen or subvert the technicality of what has become the theoretical model and, to a large extent, the reality of School. (Papert, 1994, p. 55)

Nearly three decades after Papert's statement, it can be asserted that, unfortunately, there has still been no significant shift in the perception of digital technology use in education in Brazil. What remains prevalent is the reduction of computing to computer classes, where students primarily learn to use text documents and conduct internet searches.

Thus, the integration of computer science concepts into other areas of study can foster the development of critical thinking, aiming to promote fluency in the use of computational knowledge to express solutions and cultural manifestations in a contextualized manner. This multifaceted nature of computing, coupled with the social, political, and economic context of citizens living in a society increasingly shaped by the digital world, enables the promotion of a polytechnic education for individuals (Saviani, 2003).

COMPUTATIONAL THINKING AND TEACHER TRAINING

The professional trajectory of teachers differs from that of other professions, as it begins with their first contact with school life as students. Although they initially assume a different role, their observation of the teaching profession, whether intentional or not, tends to shape their path, influence their professional profile, and initially define their teaching style.

Results of research carried out by Tardif indicate that

> the "teaching knowledge," to the extent that it requires life knowledge, personalized know-how, and skills that depend on the personality of the actors, on their personal expertise, has its origins in the teachers' family and school life histories. It also shows that the relationship with the school is already firmly structured in the novice teacher, and that the later stages of their professional socialization do not occur on neutral ground. Finally, it indicates that the learning time for work is not limited to the duration of one's professional life, but also includes the personal existence of the teachers, who, in a certain way, learned their trade before starting it. (Tardif, 2014, p. 79, author's emphasis)

In this sense, when teachers perceive the act of teaching as a natural predisposition, Tardif (2014) reminds us that the path to the teaching profession is gradually constructed until the moment this choice is consciously made.

In addition to initial teacher training, ongoing professional development must be

> A training not only in notions or disciplines, what we might call "objective knowledge," although this term is not entirely accurate, but rather a training in a greater "subjective knowledge": self-concept, conflict, self-awareness, communication, group dynamics, collective decision-making processes, etc. (Imbernón, 2010, p. 43)

Continuing education should not be regarded as an isolated event disconnected from the challenges faced by teachers. Beyond strictly technical knowledge, it should encourage reflection on "different dimensions that characterize the essence of the practice" (Freire, 1996, p. 68). A recurring issue in continuing education is the imposition of top-down training that fails to consider local contexts and the subjectivity of teachers. Often, these training programs are pre-designed, ready to be consumed by teachers, who, within this model, are perceived as passive recipients rather than active participants in their own learning process. "In this case, the learner functions much more as a patient of the transfer of the object or content than as a critical, epistemologically curious subject who constructs knowledge of the object or participates in its construction" (Freire, 1996, p. 69).

Taking into account the challenges faced by teachers during the COVID-19 pandemic, the need for ongoing training in the use of digital technological resources became evident. As the pandemic persisted and worsened, the return to in-person classes became impractical.

Thus, the challenges imposed on teachers during the pandemic led these professionals to expand their teaching possibilities through short courses.

As a result of these emergency training sessions, many teachers began using digital tools and resources solely to meet the immediate demands placed upon them. However, according to Bulegon and Mussoi (2014), digital learning objects[1] (DLO) incorporate pedagogical concepts that more effectively align with each teacher's educational practice.

From this perspective, the Scratch educational platform aligns with the progressive educational approach of humanism, which takes the Brazilian educator Paulo Freire as a reference.

1 A digital learning object is any digital resource that can be used to support learning.

This perspective views the teacher as a facilitator of self-realization and personal growth, allowing students the freedom to make choices (Bulegon and Mussoi, 2014).

Scratch was developed by the Media Lab group at the Massachusetts Institute of Technology (MIT), and is widely recognized as a teaching resource for computer science. Its popularity stems from its ability to abstract the more complex aspects of programming languages through a visual, block-based programming approach.

Given the possibilities of using Scratch in education, this block-based language was chosen to conduct activities during the CT course. Its intuitive interface is considered suitable for new users, facilitating the teaching and learning process of initial programming concepts. Scratch can be used by individuals of all ages, is independent of specific curricular components, and aims to stimulate creative thinking, systematic reasoning, and collaborative work (SCRATCH MIT, 2021).

Thus, understanding the role of teachers in their training process involves creating a dialogical path between the university and the school (Tardif, 2014) that promotes professional development by addressing the real needs of these professionals.

THE METHODOLOGICAL APPROACH

This scientific and technological research is characterized as applied in terms of its nature, qualitative in its approach to the problem, and exploratory in its objectives (Günther, 2006; Gil, 2008).

Given the importance of the researcher's approach to the research subjects and the ongoing reflection on teaching practice, applied research was chosen as the method. This approach emphasizes educational practice in relation to the context in which the research participants are situated.

> Applied research arises as the need to fill a gap in the field of methodological approaches in educational research, as it seeks to design, develop, and apply interventions on the ground of educational spaces. (Nonato and Matta, 2018, p. 14)

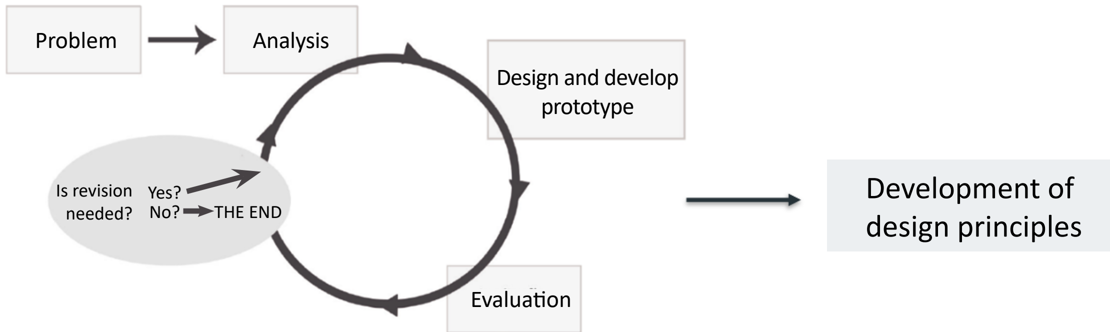
The use of applied research is recommended when the problem to be investigated lacks clarity regarding the strategies, resources, and procedures to be employed. Such situations are referred to as open problems, where the starting point(s), objectives, and methods to ensure progress from one stage to another are unknown or uncertain (Kelly, 2018).

Thus, this research is considered an open problem, as there is a gap in research designs for teaching CT that considers the participants' area of activity; a lack of educational resources to support the development of CT activities; a lack of awareness of the research topic among the participating teachers; and the inefficiency of continuing education policies, which leads to demotivation among teachers to initiate and even complete training sessions.

Due to its investigative nature, this research is similar to development studies as defined in applied research. Development studies focus on interventions aimed at finding solutions to open problems while generating reusable design principles. These principles are defined by Plomp (2018) as heuristic propositions created within a specific context, which evolve into increasingly reusable theories when validated in different contexts.

Figure 2 presents the research-application cycles. Initially, the problem to be investigated is defined, followed by an analysis of the participants involved in the intervention; then, prototypical solutions are designed, tested, and validated during the evaluation stage; based on reflection and the creation of documentation, design principles (theory) are produced to refine the implemented solution. This cyclical process is repeated until the researcher concludes that there is no further need to revise the developed prototype or until it is deemed sufficient for the scope of the research.

Figure 2 – Research-Application Cycles.



Source: adapted from Plomp (2018).

Carrying out two or more iterative cycles in research-application provides a refinement of the intervention, since

> Most educational research projects aim for only a cycle of empirical testing, whether quantitative or qualitative, at a given point in time regarding a particular intervention, with the sole purpose of producing knowledge. Applied research, in turn, seeks to progressively and dynamically produce (exploratory research), improve (constructive research), and learn (empirical research), concerning a particular phenomenon through interconnected cycles of design and research. (Bannan, 2018, p. 142)

From the perspective of research-application, an online course was designed, implemented, and validated in two cycles as a proposal for continuing education to integrate CT into the pedagogical practices of teachers in PTE. The course was conducted online and lasted a total of 15 hours, comprising 11 hours of meetings with the researcher and 4 hours of offline activities. Google Classroom was the chosen platform to organize the course content, while online meetings were held on Google Meet.

In this context, Group 1 represents the initial version of the prototype, while the week between Cycle 1 and Cycle 2 is designated for the evaluation stage, assessing the progress made. This phase identifies the aspects to be retained and those requiring revision.

The participants in this study consisted of five teachers from EMI, working in the areas of agronomy, physical education, English, food technology, and mathematics at *Instituto Federal Baiano*. The intervention was structured into two cycles, each involving a class of up to five teachers. Cycles 1 and 2 correspond to the design, development, and evaluation of the training course with the first and second classes, respectively. Each cycle had a duration of 15 hours, with evaluations conducted at the conclusion of each cycle.

The intervention involved the participation of a pedagogue throughout both cycles. Her primary responsibilities included observing the course delivery and providing guidance to participants during the development of lesson plans. In the context of continuing education, "monitoring through observation by colleagues or advisors ensures the transfer of more complex teaching strategies" (Imbernón, 2010, p. 38).

Three instruments were employed for data collection: a diagnostic questionnaire, a field diary, and a descriptive report.

The diagnostic questionnaire was distributed via Google Forms a few days before the course began, with the purpose of gathering information from participants to prepare the environment in Google Classroom. The field diary served as a tool for recording observations and notes, primarily to support the evaluation conducted at the end of each cycle. The descriptive report functioned as the main instrument for analyzing the data generated throughout the course.

Following the completion of both cycles, the analysis and interpretation of the data commenced, leading to the final preparation of the educational product.[2]

To understand both the manifest and latent content of the messages, content analysis was employed as the technique for data analysis and interpretation. This technique comprises three stages: pre-analysis, exploration of the material, and treatment of the results, followed by inference and interpretation of the data (Franco, 2005; Bardin, 2016).

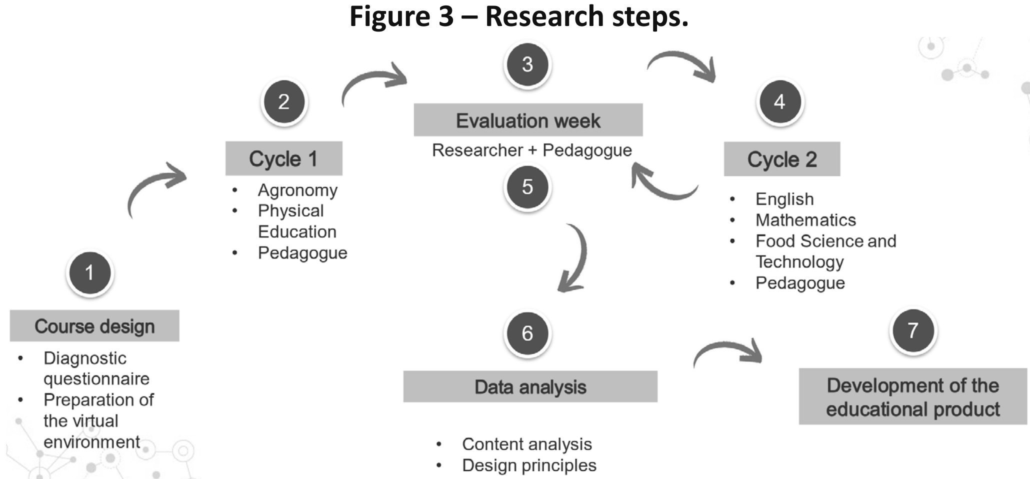
During the pre-analysis stage, the descriptive reports were reviewed to identify the most prominent themes in the participants' responses. This activity, referred to as "floating" reading, involves "establishing contact with the documents to be analyzed and familiarizing oneself with the text, allowing impressions and orientations to emerge" (Bardin, 2016, p. 126).

In the second stage, the material was coded into recording units to identify the emerging themes within each paragraph. The selection of the theme as a recording unit was based on its frequent use in studies, aiming to understand the motivations behind opinions, attitudes, values, and responses to open-ended questions and interviews (Bardin, 2016). The 16 themes were then organized into four intermediate categories based on their thematic similarities. Finally, these intermediate categories were consolidated into two final categories.

The third stage involved processing the data by making inferences from the survey form, field diary, and descriptive reports to interpret not only the most evident and, at times, already known aspects of the participants' responses, but also the latent aspects that might initially go unnoticed.

In summary, after the bibliographic research and participant selection, the research steps were as follows: (1) design of the course for the two classes based on the information gathered from the diagnostic questionnaire; (2) implementation of Cycle 1 with the first class; (3) evaluation week of Cycle 1; (4) implementation of Cycle 2 with the second class; (5) evaluation week of Cycle 2; (6) analysis and interpretation of data; and (7) preparation of the educational product. These steps are illustrated in Figure 3.

Figure 3 – Research steps.



Source: the authors (2021).

DATA ANALYSIS

This section presents the organization and interpretation of the information collected through the diagnostic questionnaire, field diary, and descriptive report. Content analysis was employed to code the data, group it into emerging categories, and make inferences based on the information.

2 Available at: http://educapes.capes.gov.br/handle/capes/601151. Access on: Jul. 31, 2021.

After regrouping the intermediate categories to identify productive and relevant terminal categories, the following final categories were established: collectivity and teaching singularity, and theoretical and methodological reflections on CT. The coding of these categories is presented in Chart 1.

Chart 1 – Data coding of the research after categorical analysis.

Theme	Intermediate Category	Final Category
1. The choice of teaching	The teaching trajectory	The collectivity and singularity of teaching
2. Initial training		
3. Teaching challenges		
4. Change in the teaching method		
5. Motivation to take the course	Challenges of continuing education	
6. Available time		
7. Short-term course		
8. Concept of CT before the course	Perceptions about CT	Theoretical and methodological reflections on CT
9. Concept of CT after the course		
10. Theoretical aspects of CT		
11. Playfulness		
12. Transversality		
13. Relevance of CT	Course contributions	
14. Autonomy		
15. Possibilities of the course in pedagogical praxis		
16. Possibilities of using Scratch in teaching practice		

Source: the authors (2021).

ANALYSIS CATEGORY: COLLECTIVITY AND TEACHING SINGULARITY

This category addresses the teaching career and the challenges encountered in continuing education. Given the subjectivity and the historical, economic, and social contexts of each teacher, they can be considered unique and distinct in their worldview, teaching knowledge, and professional practice. “No two teachers are the same. Each one must find their own way of being a teacher, their pedagogical composition” (Nóvoa, 2017, p. 1125). However, these teachers also share many common aspects, such as their career, objective working conditions, and the act of teaching, thus reflecting both the collectivity and singularity of these education professionals.

As stated by Freire (1996), teaching is a human specificity that demands research, respect for students’ knowledge, critical thinking, an understanding of reality, curiosity, risk-taking, and acceptance of the new. It involves the conviction that change is possible and the ability to think critically about one’s practice. Teaching is the recognition that education is a form of intervention in the world, not merely the mechanical act of transferring knowledge.

Teachers are the active protagonists of their own training, seeking strategies that help address problem situations encountered daily in their workspace. When possible, they choose contextualized courses, resisting a top-down approach to training that overlooks the conditions and needs of the teaching reality (Imbernón, 2010).

The lack of space dedicated to continuing education in teachers' work plans has been one of the primary barriers in the continuing education process. In addition to the educational institution not offering institutional courses focused on continuing education, there are no incentives for participation in qualification programs, such as reducing the workload. As a result, teachers are compelled to seek courses that address only the most immediate pedagogical demands, leading to training that is often reactive rather than proactive.

ANALYSIS CATEGORY: THEORETICAL AND METHODOLOGICAL REFLECTIONS ON COMPUTATIONAL THINKING

This category encompasses all aspects that were shared, discussed, and developed regarding CT throughout the course, beginning with the participants' initial ideas about CT.

As the concepts of CT were explained, the participants established initial connections with the content of their specific areas, identifying and providing examples of classroom practices that incorporate the pillars of CT.

The questions and attempts at associations raised by participants during the first week highlighted the need for a more in-depth theoretical discussion of CT, particularly with Cycle 1. Considering the limited time allocated for this discussion as one of the factors, it is evident that the difficulty some teachers face in understanding the concepts of CT is related to the degree of affinity between CT and their area of expertise. In fields such as the exact and earth sciences, it is common to model problems through quantification and "mathematization" of elements. Furthermore, teachers' lesson planning does not always incorporate problematization as a teaching approach.

It is crucial to consider various teaching strategies when introducing CT concepts to teachers in specific fields, as CT aims to integrate computing knowledge and skills through necessary insertions and/or adaptations to lessons without directly interfering with teaching practice ((Yadav, Stephenson e Hong, 2017). In this regard, the Brazilian Computer Society (SBC) emphasizes that computing should be taught intentionally, taking into account the specific knowledge addressed by the discipline (SBC, 2019). Therefore, it is important for teachers involved in activities related to the four pillars to develop CT, ensuring that these moments carry intentionality and meaning that extend beyond the programmatic content.

The presentation of unplugged activities did not stimulate discussions about potential uses of these resources among participants, likely due to the lack of teaching materials applicable to their curricular components and the fact that many of these activities are designed for elementary school students. This scarcity of teaching materials on PC for various educational levels was addressed in the work of Almeida *et al*. (2021).

Thus, the point at which CT concepts were put into practice for all participants occurred during the Scratch presentation. The programming sessions with Scratch highlighted the excitement of discovering programming, the joy of seeing original applications come to life, and the participants' creative engagement, adding an element of playfulness to the learning process.

In the practice of programming with Scratch, participants were encouraged to develop numerous skills related to the pillars of CT. Coding the solution in a sequence of steps (algorithms) involves abstracting the problem representation into computer language, decomposing the problem into smaller parts, and recognizing repeating code patterns through the appropriate use of recommended repetition structures.

Regarding teachers' confidence in working with CT intentionally and independently in activities, based on the course discussions, it was observed that additional training opportunities are needed to further develop and encourage teachers to use CT for themselves, their peers, and their students.

In light of the reflections prompted by the discussions on CT in education and considering the activities developed, the participants expressed the possibilities the course offered for enhancing their pedagogical practice.

> This course opened my mind to the possibility of using gamification and other strategies to stimulate Computational Thinking in my pedagogical practice. I have already started researching and even using assessment processes based on these resources. I intend to study and use these strategies more and more, as I see them as the future of education. (Teacher B)

> The first contact with the content of this course made me reflect a lot on how to plan my lessons, consciously relating them to the recognition of patterns, algorithms, abstraction, simulation, and decomposition. Now, with this theoretical framework, it is possible to design lessons thinking about each of these pillars separately, as well as conceiving them in an interconnected way in a single activity, aware of the difficulty in identifying where one begins and the other ends. (Teacher C)

One of the recommendations proposed by Yadav, Stephenson e Hong (2017) for incorporating CT into teacher training is the collaboration between computer science educators and teachers from specific subject areas. This interaction should occur through courses that integrate methods and technologies aimed at education, allowing CT to be applied to the objects of study in various fields. In this way, teachers can use a variety of educational resources that engage with CT, seamlessly integrating them into the content they teach, and developing these skills in both themselves and their students. Therefore, mediation by computer science teachers remains essential in this training context to present the possibilities for developing CT-related activities through the selection, creation, and use of the most suitable resources based on each teachers' particularities. In this context, trainers in continuing education (in the role of researcher) assume the role of practical collaborators within a more reflective model, assisting in diagnosing the problems presented by the participants, sharing their knowledge, and refraining from positioning themselves as the solver of others' problems (Imbernón, 2010).

DISCUSSION OF DATA ANALYSIS

Based on the experiences from the course on CT for teachers, it was observed that time availability was the primary obstacle to the development of activities. Two key issues were highlighted: (i) even among those who participated in the course until the end, some struggled to arrive at the scheduled start time or were unable to participate on certain days; and (ii) some teachers did not have access to most of the materials made available on Google Classroom. It was noted that other academic activities of these teachers took precedence over the course, a common scenario in most public education institutions in the country regarding continuing education (Basniak and Soares, 2016).

The issue of the number of research participants was used as a starting point for this discussion to emphasize the challenges teachers face regarding continuing education. Teachers seek and desire the constant improvement of their pedagogical practice through action-reflection, not opposing formative moments, but requiring public policies that provide the necessary conditions to engage in this lifelong learning process (Mészáros, 2005; André, 2010).

Given the schedule of competing activities, the course was planned to last two weeks to avoid overburdening the participants. However, the teachers expressed a desire to engage in the activities, particularly with Scratch, for a longer period. This leads to the following contradiction:

while teachers would prefer a longer course to address more in-depth issues related to CT, they lack the time to complete it. The cause and solution to this dilemma lie with institutional and government managers, who must create concrete opportunities for continuing education to be effectively offered and utilized, with a professional workload that is appropriately balanced in terms of both quantity and quality of time. Situations like this highlight how the continuing education of these education professionals has been neglected.

As an alternative to address the challenges of continuing education, particularly the lack of time, self-training courses and/or online platforms offering CT resources are created, such as the *Introduction to Computational Thinking* course available on MEC AVA.[3] Initiatives like these broaden access to CT content; however, they are often presented as the sole solution to the problem of continuing education, implicitly shifting the entire responsibility for the continuity of the training process onto teachers.

In this scenario, teachers have access to online resources, and it is up to them to decide whether or not to take the course. As pointed out by Falcão (2021), the learning process is not as quick and easy as often portrayed on online platforms designed to teach CT content. Many Brazilian teachers have a low level of digital fluency, making initial access to these training activities challenging. Therefore, self-training courses and online resources should not exist as isolated islands of training but should be designed and integrated into a project that addresses the real needs of teachers.

The mediation conducted in the course on CT in this research proved to be highly relevant. The opportunity for researchers to listen to the participants and learn from them reinforces the idea that formative processes should occur in a dialogical manner, through a continuous act of listening by the speaker (Freire, 1996). In this context, reflecting on the moments experienced during the course, the presentation of the lesson plans represented the creation of an environment in which each participant explained their ideas on how they would implement CT in their field of activity. This moment, marked by both speaking and listening, highlights the limitations of verticalized formations in training formats that disregard the holistic human development of the individuals involved (Freire, 1996).

Computer science should not be viewed as technical knowledge to be added to the teacher's "knowledge box," as this perspective does not align with its transversal nature, akin to Papert's discussion on the role that computers should play in schools (Papert, 1994). Therefore, the goal is not to train specialists who master the content and are responsible for disseminating it worldwide, nor to train "mass programmers" by teaching people how to program. Rather, computer science drives, through interdisciplinarity, the defragmentation of human knowledge toward the long-sought transdisciplinarity envisioned by Morin (2015).

In this regard, Couto (2017) emphatically states that, when considering theoretical assumptions, it is possible to view CT from a liberating perspective when there is: intentionality in guiding individuals toward reclaiming themselves as technological subjects; social empowerment through the critical use of technologies; an inclusive approach to providing knowledge and access to the digital world; the expansion of senses through global connections facilitated by technological devices; demystification of technology by examining its social implications; and transformative dialogue on topics related to CT. From this perspective, it becomes possible for individuals to engage in a contextualized reading of the world, provided that CT is not conflated with basic computing content and reduced solely to the act of programming computers.

3 Virtual learning environment of the Ministry of Education (*Ministério da Educação* — MEC). Available at: https://avamec.mec.gov.br. Access on: Jun. 01, 2021.

In light of these reflections, the viability of research-application as a methodological approach in educational research becomes evident, where the researcher engages directly with the subject of their study. When employed from a liberatory perspective,

> applied research fosters the creation of a learning community (subjects of praxis and researchers), since there is no study anchored in this approach without the existence of a community. Furthermore, applied research assumes failure as a relevant element for its development, as pointing out the failures of the research requires understanding the error as a success, given that this is an approach that does not conclude the research, as it does not reach the truth. (Souza, 2019, p. 9)

The cyclical iteration of the research-application allowed for the correction and adaptation of the flaws observed during the course's development, given the time constraints. At the end of the two iterations, a set of design principles was developed, which may serve as valuable guidelines for other researchers aiming to conduct similar interventions.

Plomp (2018) presents Jan van den Akker's (1999) model as a framework to assist researchers in developing design principles from applied research:

> if you want to design <an intervention X> for <purpose/function Y> in <context Z>, your best option is to give <this intervention> <characteristics A, B, and C> [substantive emphasis] and do so through <procedures K, L, and M> [procedural emphasis] because of <arguments P, Q, and R>. (Plomp, 2018, p. 39)

Based on the above proposition, six guiding items for the development of design principles can be identified: intervention, purpose, context, essential characteristics, necessary procedures, and arguments. Considering the discussions and findings presented in this research, Chart 2 outlines the proposed design principles, incorporating the six characteristics deemed essential.

The first characteristic emphasizes the involvement of a pedagogical advisor to assist researchers/trainers during the intervention through observation, note-taking, and participation. The goal is to complement the content on CT by highlighting its connections with existing pedagogical theories. Furthermore, the pedagogical advisor can offer a more conceptual approach to certain lesson plan topics, encouraging participants to reflect on how CT can be more seamlessly integrated into their classes.

The second characteristic aims to avoid verticalized training by ensuring that participants have an active voice in the training space. It encourages them to share their successful and unsuccessful experiences, discuss the challenges they face in the classroom, and reflect on how CT can be applied in their specific areas of activity.

Thus, it becomes possible to use teaching materials that are tailored to each participant by understanding the educational context in which these teachers are situated. This approach allows for the selection and provision of CT resources that are most relevant to their practical needs.

The fourth characteristic recommends maintaining a field diary to document the events of each intervention meeting. Due to the subjectivity of the participants, actions are imbued with meanings, and it is crucial to observe and interpret them. Additionally, various internal or external interferences may arise during the intervention that can influence the progress of the activities. Therefore, it is advised that researchers/trainers maintain these records through careful observation.

The fifth characteristic suggests that each participant prepares at least one lesson plan. This allows teachers the freedom to select a lesson in which they would like to incorporate CT. However, since not all teachers consistently document their lesson plans, it is essential to organize

Chart 2 – Presentation and proposal for the organization of design principles generated in the research.

Design Principles		
Intervention	Implementation of an online course on CT	
Purpose	To promote continued education for teachers	
Context	PTE/EMI (no distinction of area)	
1. Essential Characteristics	**2. Necessary Procedures**	**3. Arguments**
Structuring the course considering pedagogical aspects during the planning and development of activities.	Collaboration with at least one pedagogical advisor.	Contributions from the pedagogical advisor regarding the organization and pedagogical follow-up of the course, along with a contextualized view of various pedagogical theories.
Active participation of each participant, sharing their praxis and classroom challenges.	Encouraging dialogue between course participants and the researcher/trainer; plan the course to allow enough time for participants to express themselves.	Dialogue between researcher and participants is essential in creating contextualized and meaningful solutions.
Use of appropriate materials for each participant.	Searching for materials on CT that fit each participant's reality.	Individualizes and generalizes the concepts of CT in the participant's area of study, enabling more horizontalized and contextualized training.
Use of a field journal.	Taking notes on participants' perceptions during the presentation of CT concepts, motivational aspects for taking the course, and performance in completing the proposed activities.	The relevance of verbal and non-verbal communication between participants during the course provides insights that guide evaluation and planning of the cycles.
Development of a lesson plan by each participant.	Encouraging each participant to choose a lesson in which they would like to integrate CT and help them in constructing objectives and methodological procedures.	Structuring the lesson plan helps participants understand how to integrate CT into their current work plan
Block programming	Using online platforms that do not require participants to install software.	Programming develops various skills, giving concreteness to often abstract CT concepts; Scratch's block language has proven to be a viable alternative for this activity.

Source: the authors (2021).
CT: computational thinking; PTE: professional and technological education; EMI: integrated secondary education (*ensino médio integrado* — EMI).

and record ideas. Participants are expected to provide details of the procedures carried out in the lessons so that, along with the researcher and pedagogical advisor, they can identify alternative approaches for integrating CT concepts into the chosen class.

The last characteristic, block programming, involves conducting practical plug-in activities related to CT and directly linked to computer science. It is recommended to use a more visual language to introduce programming concepts, facilitating abstraction from the complexity of languages used for commercial purposes. To minimize issues related to software installation and operation, the use of online platforms with pre-configured and intuitive environments is advised. In this research, Scratch was chosen due to its widespread global acceptance and its versatility in creating stories, games, and animations, aligning with the interests of each participant.

Although researchers using applied research do not necessarily aim to classify their studies as development or validation studies, the present research exhibits characteristics of both categories, with a stronger emphasis on development studies.

During the bibliographic research stage, no studies were found that explicitly present validated design principles for reuse, particularly in the implementation of online courses. Additionally, publications on CT in PTE remain scarce, resulting in a limited availability of teaching materials to support teacher training. Such scenarios are suitable as starting points for development studies, as "there are no — or only a few — validated principles available to support design and development activities." (Plomp, 2018, p. 38).

In short, it is necessary to empower teachers to take an active role in continuing education spaces through research methods that foster dialogue, create moments of listening, and continually enable them to address educational challenges encountered daily inside and outside the classroom. In this sense, it is important that teachers apply CT beyond the computational techniques studied in computer science, viewing it as a cognitive tool that enables individuals to develop a critical perspective on the world.

FINAL CONSIDERATIONS

Based on the motivation to research CT in PTE, this study was designed with the general objective of promoting the use of CT by teachers working in EMI. To achieve this objective, three specific objectives were established: conducting bibliographic research on the topics of CT and teacher training, planning and implementing an online course, and presenting lesson plans that integrate CT.

The first specific objective was to investigate how discussions about CT have been taking place in PTE. To this end, a bibliographic review was conducted on the CEIE publications portal, revealing the need for research on CT in the context of PTE that presents in-depth discussions on the specificities of this modality of Brazilian education. This includes establishing appropriate relationships with education, technology, society, and the production system. It is urgent to examine how the widely disseminated benefits of CT contribute to the integral formation of the subject, ensuring that it is not merely treated as another commodity of the capitalist system.

The second objective was to develop strategies and tools to enrich the teaching and learning process of teachers using CT. This objective was achieved by integrating the activities developed with Scratch into the participants' individual lesson plans. By asking teachers to select a lesson in which they would like to incorporate CT, the study first examined how its pillars were already present and how they could be further emphasized through plugged-in or unplugged activities. The discussion of the lesson plans proved to be a moment of valuable exchange among different areas of knowledge, enabling the researcher, pedagogue, and teacher to better understand the limits and possibilities of integrating CT into teaching practice. One of the challenges encountered in this research was the scarcity of resources on CT that specifically addressed the needs of each participant. Many available educational resources are designed for the exact sciences and often focus on teaching computer science concepts in isolation, without contextualizing them within other domains of knowledge, which does not align with the objectives of this research. To address this, Scratch was chosen as a tool for participants to create small, contextualized applications based on their lesson plans, without the need to explicitly teach programming concepts such as variables, loops, and selection structures, instead using them intuitively.

The third and final specific objective was to design pedagogical paths for developing a course on CT for PTE teachers. Based on the data analysis, a workshop notebook was prepared as the educational product, serving as a didactic guide to support the development of activities related to CT.

One of the contributions of this research is the proposition of design principles derived from applied research. It is essential that designs for planning formative moments are made available and accessible, allowing other researchers to validate existing principles and even develop new ones. In this sense, the essential characteristics outlined in the design principles developed in this research are expected to become reusable theories applicable to other educational contexts beyond PTE.

In general terms, it is important to emphasize that research on CT should consider the contradictions in its definitions and applications. If CT is defined as a cross-cutting theme, it should be more widely discussed in activities beyond the exact sciences, focusing primarily on the epistemological foundations of the term and concept itself. Furthermore, CT is often mistaken as merely the act of programming an electronic device due to the predominance of such activities in scientific publications. If the intention is to present CT solely as a skill for training computer programmers, a critical question arises: who or what does CT ultimately serve?

Another important discussion concerns the need to include specific curricular components for computing and/or computational thinking in the curriculum, as is being done in several countries. If CT is a transversal theme and computers must be inseparably integrated into the teaching and learning process, does the creation of additional curricular components risk fragmenting the integrated curriculum?

In response to the problem that guided the studies of this research — "What are the possibilities for including CT in the teaching area of teachers working in EMI of PTE?" — first, through the strengthening of bachelor's degree courses in computing in Brazil, since these future professionals bring the pedagogical and technical framework necessary for the development of CT in a contextualized way; second, through the implementation of policies regarding the continuing education of teachers in the search for solving the problems experienced today in the "school floor" and preparing these professionals for the emergence of new pedagogical demands, which will come at some point; and, in addition, as a complement to continuing education policies, educational institutions should strengthen the relationships between computing teachers and other areas of knowledge through interdisciplinary programs.

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