Training in Computational Thinking from a Scientific Perspective for Science Teachers

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ABSTRACT
Computing concepts are present in people's lives, whether in simple or complex tasks, such as planning a travel itinerary or programming a robot in the production of vaccines and medicines. The innovation in Computing is already part of civic, economic and personal life, and new possibilities have emerged in several areas of knowledge, among which education stands out. Computational Thinking (CT) allows students and teachers to use computing concepts to solve problems in an interdisciplinary way. In this context, teachers from different areas of knowledge are required to have skills in digital skills and in the fundamentals of computing. Aiming to collaborate with the area, we propose a research that investigates the CT from a scientific perspective for Science teachers of the Final Years of Elementary School.

Author Keywords
Teacher Training; Computational Thinking; Science Teaching; Elementary School.

ACM Classification Keywords
K.3.1 [Computers and Education]: Computer Uses in Education.

INTRODUCTION

Everyday life is increasingly computational, whether with the use of computers, smartphones, intelligent systems, automation and other computing technologies that have been developed. Computing has changed the way we live, work, and perhaps we could even say the way we think.

The schools are inserted in this context and are challenged to research the concepts of Computational Thinking [20], that is, to create possibilities of using computational processes for people to "think with machines" and "about their own thinking", in order to solve problems, through a sequence of creative actions [19].

Computational Thinking (CT) is the process of recognizing aspects of computation in the world around us and applying tools and techniques to understand and reason about natural, social and artificial systems and processes [21]. "As well as reading, writing and arithmetic, we should include CT in the analytical ability of all children" [21].

Computing allow researchers from all disciplines to visualize new problem-solving strategies and test new solutions both in the virtual and real world, knowing that the CT is a uniquely human skill [21]. The skill needed to tell a computer what to do is to program. The thought process behind programming is computational thinking, which is a uniquely human skill.

The CT is a distinct creative, critical and strategic human capacity to know how to use the fundamentals of Computing, in the most diverse areas of knowledge, in order to identify and solve problems, individually or collaboratively, through clear steps, in such a way that a person or a machine can perform them effectively [6].

In this sense, there are several efforts by research groups, the private sector and societies, such as the Brazilian Computer Society in the inclusion of CT in basic education subjects and the Reference Curriculum in Technology and Computing, developed and proposed by the Innovation Center for Brazilian Education.

The teaching of computing starts to be contemplated, even mentioned in the fifth general competence of the National Common Curricular Base for Basic Education and is related to the understanding, use and creation of Digital Information and Communication Technologies for the access to communication, dissemination of information and knowledge [2].

The CT is also included in the Brazilian resolution [2], which defines the National Curriculum Guidelines for the Initial Training of Teachers for Basic Education and establishes the Common National Base for the Initial Training of Teachers of Basic Education, which brings in article twelve [3].

The insertion of CT in teaching is a challenge in the reality of Brazilian schools. It will be necessary to go through some stages, with teacher training being one of the main ones [11].

Several initiatives generally exist with the objective of being an attempt to fill this gap, such as the website CT [17], Programaê [19], AVA-MEC [1]. However, we noticed that the CT in elementary school has adherence to the exact areas, but difficulties to reach other areas, such as Natural Sciences.

The area of science teaching involves people learning about themselves and their relationship with the world. These learnings, among others, enable students to understand, explain and intervene in the world in which they live.

Many challenges about life, presenting skills that relate to different areas, which can be based on the concepts of CT, with the objective of illustrating the scope and feasibility of integrating this strategy in teacher training.

Thinking of establishing relationships between the main concepts of CT and the skills proposed in the National Common Curricular Base for Basic Education for the different thematic units of Science, we propose research that investigates the CT from a scientific perspective in the training of Science teachers in Elementary School.

LITERATURE REVIEW

The reflection on CT became evident when using the term as a skill for all subjects universal way [15], not being restricted to just one field of action, with the possibility of building significant changes in intellectual development in the scenario educational.

According [16] the potential to provide a favorable environment in the classroom, in the same way that the author himself had already done with Logo, giving children the opportunity to learn how to program playfully, providing the student with conditions to enhance learning in different areas of knowledge.

In this perspective, Papert developed the constructionist conception, in which the student uses technology as a tool that helps him in the construction of knowledge through active learning environments that allow him to test his ideas, theories or hypotheses. In 2006, Jeanette Wing, director of research at the National Science Foundation (NSF), helped to popularize the term CT, seeking to integrate it in interdisciplinary.

According [21] the CT is a "combination of critical thinking with the fundamentals of computing that defines a methodology for solving problems, developing systems and understanding human behavior, a fundamental skill for all."

It is worth noting that the principles of computing are not only for computer programmers or computing students, but for all people, as it provides the stimulus of creativity, with structured thinking, in addition to working collaboratively.

The CT can be used attractively by teachers, in an interdisciplinary and collaborative way, creating situations that provoke in students the encouragement of ideas from their experiences and experiences, to formulate and test hypotheses, rethink and reflect on decisions.

In Science teaching, the CT strengthens students' interest and curiosity area of Science and Technology, providing a critical reflection on reality. It creates situations that provoke reflections on science teaching, in such a way that it becomes an instrument for intellectual development and social democratization through knowledge, facilitating a critical reading of the world [8].

COMPUTATIONAL THINKING IN TEACHER EDUCATION

According [3] document that defines the set of curricular guidelines for the training of basic education teachers, in which it complies with the National Common Curricular Base for Basic Education and the National Education Plan.

The learning defined by the National Common Curricular Base for Basic Education should contribute to the development of the ten competencies, aligned with the 2030 Agenda of the United Nations. In this way, we highlight item f of [3] that deals with teaching professional skills: f) basic understanding of digital phenomena and computational thinking, as well as their implications for contemporary teaching-learning processes. [3].

According [5] the CT is already a reality in the basic education curriculum of several countries in the Americas. In Brazil, until recently, there was no legal intention regarding the integration of CT into teaching.

For the CT to become a practical methodology of the curriculum, it is necessary to train teachers to create and use the CT during their pedagogical praxis [18]. However, it is necessary that there be systematic actions to train teachers to get to know or expand their knowledge about CT in teaching.

We noticed that the CT appears as an increasingly common knowledge in scientific research, its strategy in solving simple to complex problems is applied to all areas of education.

Integration of Computational Thinking in Science Skills

The Teaching of Science in Brazilian Elementary Education aims to train citizens to learn about themselves, diversity and the processes of evolution and maintenance of life, the material world with the application of scientific knowledge in the various spheres of life human.

The teacher's role is to mediate learning from the creation of digital technologies for Science Teaching using the CT as a pedagogical resource to communicate, access, disseminate information, produce knowledge, solve problems and enhance learning.

The Science discipline enables students to understand, explain and intervene in the world in which they live. It is essential to train Science teachers using the CT in their pedagogical practices to develop thinking in a structured way, using the concepts of computing, arousing curiosity, argumentation and understanding the scientific culture.

We realized when we found research in the literature that science teachers benefited from learning how to restructure the pedagogical practice in the classroom using the CT [4, 12,13, 14].

Science Teaching seeks to encourage students to reflect, discuss and seek solutions for their daily lives. According [7], the Science teacher needs to develop a proposal based on

learning with the characteristics of a scientific research, but for that, it is necessary that teachers have a training that goes beyond addressing only the resource, teaching style or theoretical orientations.

According [7] present eight aspects to be reflected and analyzed of what a new teacher education should be like, with the proposal of learning as the construction of knowledge with characteristics of scientific research. The authors point out the eight points in the light of research in science teaching, with the aim of describing what teachers need to "know" and "know how to do" in their classes.

Analyzing and reflecting on the work of these authors, we realize that the teacher's activity goes far beyond just teaching classes, it is about the teacher being a researcher. According [10], points out that it is not enough for a teacher to be just a research professional, but a "professional of education through research".

In this approach, the teacher is essential, at the moment of orientation, reflection, doubts and certainties, it is a process of construction, which demands from the teacher a new differential, a differentiated posture, becoming aware of their attitudes that cross the scope of their professional formation.

According [10] propose, research is based on four: a) the proposal of education in the sake of education is the specificity most specific to school and academic; b) the recognition that reconstructive questioning, with formal quality, is at the heart of the research process; c) the need to make research an everyday attitude in the teacher and in the student; and d) a definition of education as a process of formation of historical and human competence.

ECOSYSTEM FOR TRAINING IN COMPUTATIONAL THINKING IN SCIENCE TEACHING

To advance with the development of studies using the CT in the areas of teaching, this research brings contributions to Science Teaching through an Ecosystem on CT for Science Teachers of the Final Years of Elementary School.

Allowing the development of skills/competencies using the CT as a strategy that involves the simulation of problems so that their solutions can be represented with Computational Metamodels [9]. Teachers interact in the same environment simultaneously, in this way, creating, transforming, informing and being informed, creating learning paths from the problems and solutions experienced.

The term Ecosystem is adapted from biology, where it has long been used to describe the populations of any defined area and their interactions with each other and their shared environment.

The definition of an expression “Ecosystem” means the relationship between a natural environment (environment) and a community of organisms, as well as the interrelationships of both. In this way, all the contexts of our lives can be thought of as some kind of ecosystem, that is, frames of reference in which we interact with each other and with our environment.

The current research was motivated from the context of the CT in Science teaching, since it is being inserted in the National Common Curricular Base for Basic Education as a way to democratize knowledge in Computing in education.

The project proposed here is a training ecosystem for teachers who teach Science, as we aim to use it allied to the National Common Curricular Base for Basic Education in Brazilian schools and, due to technological problems, we suggest plugged and unplugged activities for the execution of the proposed activities during the formative process.

An example of this is AlgoCards [5], an activity using a map and through command cards ("to the left", "to the right", "forward", "backward", "one step ahead"), players need to reach certain targets on the map.

Let's suppose, then, as proof of concept, the realization of the Ecosystem by teachers from the municipal public network of Vila Velha in Espírito Santo/Brazil, which corresponds to a visit to a school, for the creation of a selective collection project, idealized as a Microworld.

The activity involves creating groups of teachers from different schools, aiming at teamwork among unusual individuals. This work may involve the diagnosis of waste that is generated in the school. The creation of a team for the logistics of collecting

INITIAL PROJECT ARCHITECTURE

We propose here an initial component-based architecture for the development of the environment, presented in Figure 1.

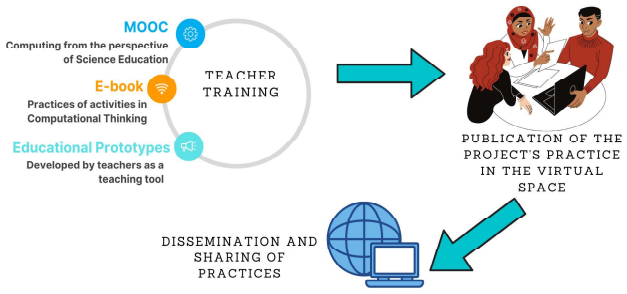

Figure 1. Prepared by the Author (2022)

The project must be available on the Internet it can be accessed from anywhere in the world, including Brazilian schools

According to Figure 1, the CT Training Ecosystem has three main moments, which will work as follows: (i) teacher training course, (ii) creation and publication of pedagogical practice in the virtual space and (iii) sharing and dissemination of the practice on the internet.

The initial layer was conceived as a Massive Open Online Course (MOOC), through which teachers can interact and learn about CT applied to Science.

As main components, the Training Ecosystem contains an environment for authoring and disseminating project prototypes, an environment for unplugged activities material (e-book) and to complement these components, a virtual space to share experiences, learning and share their productions through a database. We will briefly present the cited artifacts and their characteristics.

Course on Computational Thinking applied to Science Teaching

Forming this Training Ecosystem, we have the Massive Open Courses Online (MOOC) on Computational Thinking from the perspective of Science Education, contextualized with the Science themes of the Final Years of the National Common Curricular Base for Basic Education.

The training course was structured to provide input on the concepts of CT for Science teachers. The purpose is for it to work in a hybrid, with a 4-hour face-to-face meeting for each module. We present in Figure 2 the initial plan of the course, which is structured in nine modules, which are released as the teacher progresses.

In the first four modules, participants immerse themselves in the fundamental concepts of Computational Thinking, working on the four pillars: decomposition, abstraction, pattern recognition and algorithms.

Module	Contents
1	Fundamentals of Computational Thinking
2	Computational Thinking in the World and Brazil
3	Laboratory Experiments - Computational Thinking in Science
4	Create your own experience

Figure 2. Initial MOOC Programming by Author (2022).

Ebook Environment

The e-book will be an artifact built to help training, in it we will have some proposals for non-limited activities and based on a National Common Curricular Base for Basic Education that teachers will develop and apply during the training process. The proposal is that it be shared among teachers so that they can test the experiences and pedagogical practices in the classroom.

Virtual Space Environment

Repository of records of projects and practices developed by teachers during the training process. This space will work for teachers to report through a logbook what worked and the improvements in their developed projects/prototypes.

Authoring Environment

The authoring environment is a part of the project work, where teachers can create their prototypes, share these pedagogical practices and produce new projects based on those that already exist, that is, the possibility for teachers to be authors of their own prototypes and make it available for other to enjoy.

To build this environment, the following modules are needed: project editor, picture editor, rules editor, avatar editor and pedagogical tool's editor.

CONCLUSION

This work presented an initial proposal of a CT Training Ecosystem for teachers who teach Science in Elementary School, for the production and cooperative experimentation of CT, an experience that we believe to be, in addition to being innovative, significant for the construction of collective and individual knowledge of students and teachers.

The study investigated the inclusion of CT in the curriculum, proposing the training process for teachers in continuing education.

It was observed that several materials and programs developed in the formation of CT are directly connected with the area of Exact Sciences and few materials in the areas of Natural Sciences. Finally, this project is a doctoral thesis in progress and should be presented, with greater detail and description in future publications.

REFERENCES

[1] AVA-MEC. Ambiente Virtual de Aprendizagem do Ministério da Educação do Brazil. Retrieved August 19, 2022 from https://avamec.mec.gov.br/

[2] Brazil. Base Nacional Comum Curricular. 2018. Ministério da Educação. Secretaria da Educação Básica. Retrieved August 12, 2022 from http://basenacionalcomum.mec.gov.br/abase/.

[3] Brazil. BNC-Formação. 2019. Resolução CNE/CP. Define as Diretrizes Curriculares Nacionais para a Formação Inicial de Professores para a Educação Básica e institui a Base Nacional Comum para a Formação Inicial de Professores da Educação Básica. Retrieved August 2, 2022 from http://portal.mec.gov.br/

[4] Matt Bower, Leigh N. Wood, Jennifer W.M. Lai, Cathie Howe, Raymond Lister. 2017. Improving the Computational Thinking Pedagogical Capabilities of School Teachers. *Australian Journal of Teacher Education.* 42(3). http://dx.doi.org/10.14221/ajte.2017v42.

[5] Christian P. Brackmann. 2017. Desenvolvimento do Pensamento Computacional Através De Atividades Desplugadas Na Educação Básica. Tese de Doutorado em Informática na Educação. *Pós-Graduação em Informática na Educação, Universidade Federal do Rio Grande do Sul.* Retrieved August 16, 2022 from https://lume.ufrgs.br/handle/10183/172208.

[6] Christian P. Brackmann, Saulo V. N. Caetano, Anita R. da Silva. 2020. Pensamento Computacional desplugado: ensino e avaliação na educação primária Brasileira. *Revista de Novas Tecnologias na Educação*. Porto Alegre, v. 17, n. 3, p. 636–64. https://doi.org/10.22456/1679-1916.99894.

[7] Anna M. Carvalho, Daniel G. Pérez. 2011. Formação De Professores de Ciências: Tendências e Inovações. 10. ed. São Paulo: Cortez.

[8] Attico I. Chassot. 2003. Educação Consciência. Santa Cruz do Sul: EDUNISC, 2003.

[9] Peter J. Denning. 2007. Computer Science Science? *Comunications of ACM*, v.50, n.7, p. 27- 31.

[10] Pedro Demo. 2003. Educar pela Pesquisa. Campinas: Autores Associados.

[11] Rozelma França, Patrícia Tedesco. 2015. Desafios e oportunidades ao ensino do pensamento computacional na educação básica no Brasil. In *Anais dos Workshops do Congresso Brasileiro de Informática na Educação*. vol. 4, p. 1464. http://dx.doi.org/10.5753/cbie.wcbie.2015.1464

[12] Maya Israel, Quentin M. Wherfel, Jamie Person, Saadeddine Shehab, Tanya Tapia. 2015. Supporting All Learners In School-Wide Computational Thinking: A Cross-Case Qualitative Analysis. *Computers & Education.* 82, 263–279.

[13] Siu-cheung Kong, Ming Ming Chiu, Ming Lai. 2018. A Study Of Primary School Students' Interest, Collaboration Attitude, And Programming Empowerment In Computational Thinking Education. *Computers & Education*. 127, 178–189.

[14] Irene Lee, Fred Lane Martin, Jill Denner, Bob Coulter. 2011. Computational Thinking For Youth In Practice. *ACM Inroads*. 2(1), 32–37.

[15] Seymour A. Papert, Cynthia Solomon. 1972. Twenty Things To Do With A Computer. *Educational Technology Magazine.* Retrieved August 10, 2022 from http://www.stager.org/articles/twentythings.pdf

[16] Seymour A. Papert. 1994. A Máquina Das Crianças: Repensando A Escola Na Era Digital. Porto Alegre: Artes Médicas, 1994.

[17] Portal Computational. August 30, 2022 from https://www.computacional.com.br

[18] Elena Pietro-Rodriguez, Regina Berretta. 2014. Digital Technology Teachers' Perceptions Of Computer Science: It Is Not All About Programming. *IEEE Frontiers in Education*. Retrieved September 10, 2022 from https://ieeexplore.ieee.org/document/7044134

[19] Programae. Retrieved September 7, 2022 from https://programae.org.br

[20] José A. Valente. 2016. Integração do pensamento computacional no currículo da educação básica: diferentes estratégias usadas e questões de formação de professores e avaliação do aluno. *Revista e-Curriculum*, vol. 14, num. 3, jul.-set., 2016, p. 864-897. Retrieved September 10, 2022 from https://revistas.pucsp.br/index.php/curriculum/article/view/29051

[21] Jeannette M. Wing. 2006. Computational Thinking. *Communications of the ACM.* v. 49, n. 3, 33-35, 2006. https://dl.acm.org/doi/10.1145/1118178.1118215.