Revista ARACÊ
ISSN: 2358-2472

EXPLORING COMPUTATIONAL THINKING: AN ANALYSIS WITH SCIENCE TEACHERS FROM THE PERSPECTIVE OF ACTOR-NETWORK THEORY

https://doi.org/10.56238/arev7n1-039

Submitted on: 11/04/2024 **Publication date:** 01/03/2025

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ABSTRACT

Science Teaching has evolved continuously, driven by several factors, among which the use of Digital Technologies (DT) stands out. Computational Thinking (CT), in turn, can contribute to a deeper understanding of these advances. In this context, this research aims to describe, analyze and discuss, based on the Actor-Network Theory (ANT), the results on the perception of computational thinking by a group of teachers who participated in the training course "Computational Thinking in Science Teaching". This course, promoted by the State University of Western Paraná, through four meetings and 25-hour certification, had the participation of twelve basic education teachers, mostly science teachers from the public network. The results indicate that most of this group of teachers are unaware of the concept of computational thinking and that, even among those familiar with the subject, the answers were limited in articulation with science teaching. These data highlight the importance of promoting training initiatives to train basic education teachers, so that they can understand and apply, in a creative and effective way, computational thinking in the school context, in an integrated way with the various curricular components, especially in science teaching.

Keywords: Science Teaching. Computational Thinking. Actor-Network Theory. Teacher Training. Basic Education.

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INTRODUCTION

The contemporary technological conjuncture brings new challenges to education, with the need for restructuring and changes in educational pedagogical proposals. The preparation of professionals with knowledge to deal with a wide variety of problems and that have a critical vision and capable of proposing viable alternatives to the numerous current challenges require adaptations in the teaching and learning processes, in such a way that future generations can be instructed with specific skills and knowledge that complement the traditional components of school curricula (FERNÁNDEZ et al., 2018).

Given this scenario, there is a need to think about training that contributes to teachers having theoretical, pedagogical and practical foundations to articulate knowledge and skills related to the digital world, especially after the recent changes in the *National Common Curriculum Base* (BNCC), with the publication of the document *Computing - Complement to BNCC*, approved in 2022 (BNCC, 2022), in which Computational Thinking (CT), through the teaching of computing, became mandatory for all stages of Basic Education.

In this sense, the training course "Computational Thinking in Science Teaching" was promoted at the State University of Western Paraná. The course, in addition to serving to constitute the data of this research, represents one of the several multidisciplinary actions carried out in the extension project "Teacher Training for the Teaching of Science and Biology", and in the research project "Portrait of Teacher Training for the Teaching of Science, Biology and Health", approved by the Human Research Ethics Committee in the year 2022.

The research presented is part of a study whose objective is to investigate the challenges and opportunities in the use of CT in Science Teaching, through a teacher training course for basic education teachers. In this article, in particular, we aim to: describe, analyze and discuss, from the Actor-Network Theory (ANT), the results related to the perception and reflections on the concept of computational thinking carried out by a group of teachers who participated in the teacher training course.

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ORIGIN AND EVOLUTION OF COMPUTATIONAL THINKING: UNRAVELING THE LOGIC OF DIGITAL TECHNOLOGIES

The word computer derives from the Latin verb *computare*, which means to calculate, count or add. The abacus, considered one of the first manual calculation instruments, marks the beginning of the history of computers (PINHEIRO, 2021). Centuries later, the first mechanical calculators appeared, also recognized as precursors of modern computers (MACHADO *et al*., 2008). Thus, more than a century ago, there was already equipment capable of transferring data to machines, which were later processed and organized at a speed higher than the human capacity to carry out these processes (ALMEIDA, 2000).

In the context of technological evolution, World War II was a remarkable period for advances in computing, with the development of the first electronic computers, such as the Colossus, in 1943 and the ENIAC (*Electronic Numerical Integrator and Computer*), in 1946 (ALMEIDA, 2000). In this scenario, between 1950 and 1960, the foundations were laid that gave rise to the CT as a reflexive view of the advances in computing (AMORIM; BARRETO, 2023). By the end of the 1960s, Seymour Papert, through the LOGO language, stood out as one of the pioneers in incorporating CT into education. Between the 1980s and 1990s, he even used the expression "*computational thinking*" as a reference to this way of thinking (KAMINSKI; KLÜBER; BOSCARIOLI, 2021).

However, it was only after the publication of the article "*Computational Thinking*", by Jannette Wing, in 2006, that the CT expanded, being gradually incorporated into the basic education curriculum, initially by the United Kingdom in 2012 and, later, by other countries (AMORIM; BARRETO, 2023). In Brazil, the regulation, *Computing - Complement to the BNCC*, which governs the teaching of computing, approved in 2022, made the teaching of computing mandatory for all levels, from kindergarten to high school, through three axes: digital culture, computational thinking, and the digital world (BNCC, 2022).

Even with the expansion in the teaching of CT, there is still no single and widely disseminated conceptual definition in the literature. Wing (2006) defines the CT as a set of methods and models that uses the potential of computing to design systems aimed at solving various problems, so that they can be executed by both humans and machines.

The *Computer Science Teachers Association* and the *International Society for Technology in Education*, defines it as a process for solving problems, which includes some characteristics, such as: elaborating alternatives in a way that allows the computer or

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other tools to help solve various problems; represent data through abstractions, organize and analyze data in a logical way; automate solutions; provide solutions with the objective to maximize steps and resources; and, expand the processes and solutions for solving problems that have similar characteristics (ISTE; CSTA, 2011).

For Brackmann (2017), the CT comprises human creative, critical and strategic capacities, based on the principles of computing, aiming at solving problems in different areas of knowledge, through a logical sequence of steps that can be executed effectively, both by humans and machines. In turn, the Brazilian Computer Society describes CT as the "Ability to understand, define, model, compare, solve, automate and analyze problems (and solutions) in a methodical and systematic way" (RIBEIRO *et al.*, 2019, p. 3).

In the context in which digital culture is becoming increasingly prominent, the CT emerges as a coherent alternative to integrate technologies into current education, either through the use of digital tools in plugged-in activities or through unplugged activities[4] (KAMINSKI; KLÜBER; BOSCARIOLI, 2021). Thus, access to the skill set articulated with CT not only opens doors to new personal and professional opportunities, but also empowers individuals to understand and positively influence the technological world around them (BRACKMANN, 2017).

In this work we seek to describe, analyze and discuss the perception and reflections on the concept of computational thinking carried out by a group of teachers using the Actor-Network Theory (ANT), which is an approach that can enable the mapping of interactions between different actors and elements in an educational process (MELO, 2011). In addition, the use of ANT facilitates the understanding of the dynamics that influence teaching practice and its integration with technological innovations. Therefore, in the following section, the principles that underlie this theory and its use in the educational field are presented.

[4] According to Bell, Witten and Fellows (2011, p. i), unplugged activities, also mentioned in the literature by the expression unplugged computing, are those "that can be applied in remote locations with precarious access to infrastructure (i.e., without electricity or computers available) and can even be taught by non-computer specialists".

FUNDAMENTAL PRINCIPLES OF ACTOR-NETWORK THEORY AND ITS APPLICATION IN THE EDUCATIONAL CONTEXT

ANT is the result of research by several scholars, with particular emphasis on the Frenchman Bruno Latour. Among his many innovative conceptions is the idea that, as with anthropologists and sociologists who go to peoples with different cultures and realities to study them, scientists must be studied in their own scientific environments, that is, in their own scientific cultures (TOZZINI, 2019). In the book "*Reassembling the Social: An Introduction to Actor-Network Theory*", published in 2005, Latour reflects on how the social sciences and their main object of study, society, were being developed. When addressing the understanding of society and the social, the author criticizes the way in which the word social was being used by most social scientists, making it immersed in assumptions, to the point of having become an inappropriate word (LATOUR, 2012).

According to Latour (2012), in general, when social scientists use the term "social", they end up referring to stable things, which can be mobilized to explain certain contexts. However, for Latour it is important to relate the word social to the movement of aggregation, association of different elements, overcoming the idea of stability normally linked to the term. Therefore, we can reinterpret the fundamental intuitions of the social sciences by redefining sociology, no longer as the "science of the social", but as the study of associations (MEGLHIORATTI; BATISTA, 2018).

From this perspective, the term social does not refer to a specific type of adjective, but to a type of connection between elements that, by themselves, "are not social". This conception, initially, may seem strange, since it leads to the thought that sociology could encompass any type of grouping. However, this is precisely the idea that alternative social theory seeks to promote: the need to bring together and integrate all heterogeneous elements again, but under a new context or circumstance (LATOUR, 2012).

By making use of a word different from the usual one, Latour seeks to distance himself from conventional expressions used by what he calls sociologists of the social. Thus, it implements new elements, including the products of science and technology, which begin to incorporate society (BRAGA; SUÁREZ, 2018). In this way, he brings up non-human actors: "Bringing non-humans to the center of the sociological debate, postulating that they are endowed with agency and that, consequently, they are actors with full rights, undoubtedly allows us to understand the human even more" (LATOUR, 2012, p. 15).

Furthermore, Latour replaces the term "society" with "collective". This terminological change reflects a significant conceptual shift, with an emphasis on the dynamic interconnectedness of diverse elements and actors, as opposed to the idea of a static social entity. "The factors brought together in the past under the label of a "social domain" are simply some of the elements to be aggregated, in the future, in something that I will not call society, but collective" (LATOUR, 2012, p. 34).

By introducing the concept of the collective, it leads to the idea of a heterogeneous network of interactions that includes both human and non-human actors (MELO, 2011). According to Angeluci and Cacavallo (2017, p. 65), Latour "[...] it claims a social of hybrid composition, understood as a socio-technical collective of human and non-human entities". Through this perspective, it suggests exploring the connections that are constantly formed not only between people, but also between objects, images and other non-human elements (GONZALES; BAUM, 2013).

The author uses the term actantes or actantes, used in previous works, but which in the framework of the ANT receives a more in-depth and contextualized analysis (TOZZINI, 2019). "As I have shown before, both people who are able to speak and those who are unable to speak have spokespersons [...]. I propose to call anyone and anything that is represented an actant" (LATOUR, 2000, p. 138). In ANT, actant is used to designate any entity that plays an active role within a network of relationships, whether that entity is human or non-human (LATOUR, 2012).

Translation, another relevant concept for ANT, is defined by Latour as "[...] the interpretation given by the builders of facts to their interests and those of the people they enlist" (LATOUR, 2000, p. 178). This concept is so significant that some authors refer to ANT as "sociology of translation". In addition, translational moments have been used by researchers as a methodological approach (DELGADO; ANDRADE, 2019).

The idea of translation has roots in the studies of Michel Serres, who propose a vision in which time does not flow linearly, but in a chaotic, unexpected and complex way (DELGADO; ANDRADE, 2019). For Latour, time is not static, but fluid. He conceives of it as an interaction rather than an external force (MILANESE, 2021), so that, if the social remains stable and is capable of justifying a state of affairs, it cannot be ANT (LATOUR, 2012).

According to Tozzini (2019), translation is a term used to describe the mediation relationships performed between agents, relationships from which transformations are

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expected. For Angeluci and Cacavallo (2017, p. 65), translation is linked "[...] the communication and transformation of the actors, as well as the establishment of networks. These are relationships that always imply transformations." Each actor has his own interests and interprets the interests of the others according to his convenience. This multiple change of interests is referred to by Latour as translation (TOZZINI, 2019).

Latour "[...] differentiates the understanding of how the social is produced. One condition is to understand this production through intermediaries, another is to understand it through mediators" (TONIZZI, 2019, p. 355). The concepts of mediator and intermediary characterize the degree of relevance of an agent during a given action (MALVEZZI; NASCIMENTO, 2020). Therefore, there is a distinction between considering an actor as a mediator or as an intermediary in the network. An intermediary is one who transports or directs the force in a given direction, without, however, causing any type of transformation. On the other hand, mediators are capable of changing circumstances, distorting and modifying meaning, as they act by performing translations (CAMILLIS; BUSSULAR; ANTONELLO, 2016).

Uncertainty is another central element in the theory proposed by Latour. The moments of social production are permeated by uncertainty, as the state of things and their meanings are constantly readjusted as the actors interact. The uncertainty of these situations arises from the difficulty in predicting which actors are involved, how many there are, how they act and which other agents are influenced to act (SALGADO, 2018).

For Cavalcante *et al*. (2017, p. 3) "The sociology of associations does not present answers, but uncertainties as to the nature of groups, of action, of things, of facts, and about the way of knowing and writing about the social [...]". Therefore, there is no group, but a constant effort for group formation, an endless process. Latour states that the starting point should not be a predefined group, but rather the activity of the actants (LATOUR, 2012).

In view of the characteristics described, ANT presents a series of convincing arguments that justify its use as a methodological framework for studies in multiple areas of knowledge, including those focused on the educational context. Its approach emphasizes the relationships and interactions between human and non-human actors, offering a more comprehensive understanding of the phenomena (MELO, 2011).

In addition, the emphasis on the detailed description of the phenomena makes the production of knowledge based on observable data more accessible, expanding the depth

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of the analysis. For these reasons, we present the methodological approach of this research below, with emphasis on the analysis of the data based on ANT. This perspective allows for a more detailed understanding of the interactions between the human and non human actors involved in the structure of the socio-technical network.

CHARACTERISTICS AND METHODOLOGICAL CONFIGURATION OF THE RESEARCH

The research of this article is characterized by presenting a qualitative approach, Purposes[5] exploratory and descriptive research, applied nature[6], and procedures that involved field research[7], of the participant type. Research in education, in general, comprises a wide diversity of aspects, which highlight the need for investigations in a vast multiplicity of subjects (SOUZA; KERBAUY, 2017). These conditions give these studies a strong identification with the qualitative approach (LARA; MOLINA, 2011).

According to Flick (2009), qualitative research has particular relevance for studies involving studies on social relations, due to the pluralization of spheres that are present in these phenomena. In addition, it promotes greater emphasis on induction, starting from individual elements, to provide hypotheses, and cautiously, possible generalizations (GÜNTHER, 2006).

In the following subsections, the specific aspects related to the methodological configuration are presented, as well as the elements and choices that underlie the adopted methodology.

RESEARCH PARTICIPANTS

The training course was attended by twelve participants, mostly teachers of sciences and biology of public schools, from three municipalities in the western region of Paraná. Of these, only one works as a science teacher in a private school. Nine of these participants were teachers of Science in Elementary School or Natural Sciences and their

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[5] Research with exploratory purposes aims to clarify concepts or ideas, in order to later formulate more precise problems or even test hypotheses, through new studies. Descriptive research, on the other hand, seeks to identify the fundamental variables involved in a specific situation or behavior and describe them in detail (BORTOLOZZI, 2020).
[6] Almeida, Leite and Tuani (2016) define the applied nature as a characteristic of research that aims to generate practical knowledge, focused on solving specific problems and related to specific interests.
[7] As for the procedures, field research involves investigations that, in addition to the bibliographic or documentary review, also contemplate the constitution of data, which may occur in different ways, such as through participant research. One of the main characteristics of participatory research is the identification and involvement of the researcher with the people investigated (GERHARDT; SILVEIRA, 2009).

Technologies in High School. The others taught other curricular components. This group of teachers constitutes a non-probabilistic sample, since they voluntarily enrolled for the course"Computational Thinking in Science Teaching". To protect anonymity, participants were identified by a capital letter of the Portuguese alphabet.

CONSTITUTION OF DATA

The participants were invited to voluntarily participate in the research, under the conditions described in the Informed Consent Form (ICF). For the constitution of the data, it was chosen, throughout the four meetings of the course, to use different instruments, in order to capture the multiple nuances of the study. These instruments involved the use of questionnaires, validated by the members of the Research Group on Science and Biology Education, at Unioeste de Cascavel; audiovisual recordings, *in loco* in face-to-face meetings, and *online*, through the Microsoft Teams Meeting®, for the synchronous virtual meeting; and the preparation of field notes. Part of the questions that make up the questionnaires were extracted in full, with prior authorization, from the EduTec Guide (2023), prepared by the Innovation Center for Brazilian Education (ICBE), or partially modified to meet the objectives of this research.

For the data that we describe and analyze in this article, in particular, we used an objective question, from one of the questionnaires applied in the first meeting of the course, and complementary information from field notes, in order to respond to the specific objective, mentioned in the introduction.

CHARACTERISTICS OF THE COMPUTATIONAL THINKING TRAINING COURSE IN SCIENCE TEACHING

The course "Computational Thinking in Science Teaching" with 25-hour certification by Unioeste Cascavel, was designed with the objective of assisting in the training of basic education teachers, and sought to promote an integration between theory and practice in the educational context. The course was held between November 2023 and March 2024, through four meetings. The first three took place in person, providing participants with a direct and interactive learning experience, while the fourth and last meeting took place in a synchronous virtual way, via Microsoft Teams Meeting®.

In addition to investigating the understanding of the concept of CT by this group of teachers, which is the objective of this article, plugged and unplugged activities were also

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developed and carried out, in which CT was related to the teaching of science and biology. During the course also the concepts, history and documents that guide and standardize the teaching of CT for basic education in Brazil were presented, as well as moments of reflection and discussion about opportunities and challenges that the participants observe in the school units where they work, to incorporate CT into the teaching of science.

STRUCTURE FOR DATA ANALYSIS

For the data analysis was used on the assumptions of the ANT, according to which the various variables take the form of actants and are evidenced through the multiple relationships that can sprout and be performed among them. To this end, the approach through ANT requires the ability to observe social reality through the conception of a network of associations, originated in the mapping of social interactions produced by the actants, intermediaries and mediators themselves, arising from the richness of the descriptions of their traces (BRAGA; SUÁREZ, 2018).

According to Melo (2011), these associations provide more opportunities to produce new objects, in relation to the current model of science, which seeks the accuracy of replication and, consequently, falls into repetition, sometimes unnecessary and fruitless. Associations, in turn, are more fertile in producing differentiations and, therefore, much richer for ANT. Therefore, "A good story would be, then, one that is capable of weaving a network" (LATOUR, 2012, p. 189). This network is elaborated from a very detailed and descriptive narrative of the facts and actions of the actors, addressing the intermediaries, but in particular, the mediators and their ability to influence the action of the other actors in the connections and translations that take place (BRAGA; SUÁREZ, 2018).

In addition, according to Angeluci and Cacavallo (2017), the flexibility and dynamism of ANT are particularly suited to capture the ever-evolving nature of teaching, learning, and teacher training practices. Because it is not tied to fixed categories, the ANT allows you to follow the movement and transformations of educational networks over time. This better reflects the dynamic reality of educational institutions (MILANÊS, 2021).

Finally, the ANT approach can be a valuable instrument in the identification of new educational practices. By tracking how new ideas and technologies are adopted and adapted, it is possible to offer *insights* valuable information on processes of change and improvement in science education. Thus, ANT, with its descriptive and inclusive approach, provides a robust, strong methodological basis (COUTINHO *et al*., 2016) and innovative for educational research.

In ANT, no entity is defined essentially. Therefore, one of the first steps of the researcher is to carefully define "[...] the actant(s) – (for example, person, group, idea, concept, material object, plants, animals, etc.) – that will be followed" (COUTINHO; VIANA, 2019, p. 19). This definition is not fixed, but dynamic, recognizing that entities acquire meaning and relevance within the networks of relationships in which they are inserted. Concomitantly, by carefully following the development of actions in the networks, through the concepts of mediator and intermediary, it is possible to observe when the actors establish new alliances, as well as when a fact solidifies (MALVEZZI; NASCIMENTO, 2020).

These motifs, which encompass a wide range of issues and perspectives, converge to an integrated understanding of the interrelationships between science education, CT and the sociological aspects of the educational environment. This confluence of factors clearly demonstrates the complexity and interconnectedness of the elements involved, thus justifying the choice of ANT as the most appropriate methodological approach to the study objective addressed in this research.

Therefore, the methodological path followed in this investigation will be presented below, which is based on the premises of the ANT. The analysis of the data supported by the ANT was conducted sequentially, considering the chronological order of the course, in order to respond to the various specific objectives that coincide with the order in which the course was held. In this article, in particular, we focus on describing, analyzing and discussing one of these objectives, identified during the first meeting.

This structure of analysis was designed in order to highlight the actants from the formation of groups or groupings, involved with each of the specific objectives investigated. The connections and translational interactions involving mediators and intermediaries, respectively, were described based on the traces of the human and non human actors involved in the formation of these clusters and analyzed having as a guide the specific objective in question and the interactions observed by the formation of the different clusters involved in the established socio-technical network.

To this end, the following aspects were considered: **Identification of Actors; Relationship Mapping; Formation of Groupings; and the Dynamics and Impact of**

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Relationships. This framework, developed in a predominantly descriptive manner, will involve three steps:

- *First Stage*: Initially, a representation of the structure of the socio-technical network will be made, having as a starting point the formation of the groupings. This training will be structured from the traces left by the various actors involved, whether human or non-human. Then, a perspective will be drawn to illustrate how these traces contributed to the configuration of the clusters, and thus offer a view of the dynamics that form the network.
- *Second Stage*: Subsequently, the nature of the actants and the relationships established between the different groups formed will be described. This stage will focus on the interactions between intermediaries and mediators, highlighting the connections and translations that occur between the different groupings of the network. The analysis will delve into these interactions, highlighting how mediators influence relationships and how intermediaries have played their roles in the cohesion and functionality of the socio-technical network.
- *Third Stage*: A description of the evidence that relates to the specific objective of the *analyzed Moment* will be carried out. This evidence will be contextualized to demonstrate how observed interactions align with the specific objective, offering *insights* into the dynamics described. This step will serve to connect previous observations and analyses to the objective under study. Finally, the results obtained will be discussed with different bibliographic references, for a more in-depth interpretation of the observed interactions.

RESULTS AND DISCUSSIONS

The CT as a curricular component is recent in most Brazilian schools and became mandatory only in 2022. In order to analyze the perception of the course participants in relation to the concept of computational thinking, I begin with a description of the formation of the groups constituted during this stage of the training course.

This description covers both the elements and objects used and the people who actively participated in the action, from the initial process to the configuration of the structure of the socio-technical network of the *A moment* under analysis. Figure 1 illustrates this network, allowing a visualization of the interactions that developed, from the

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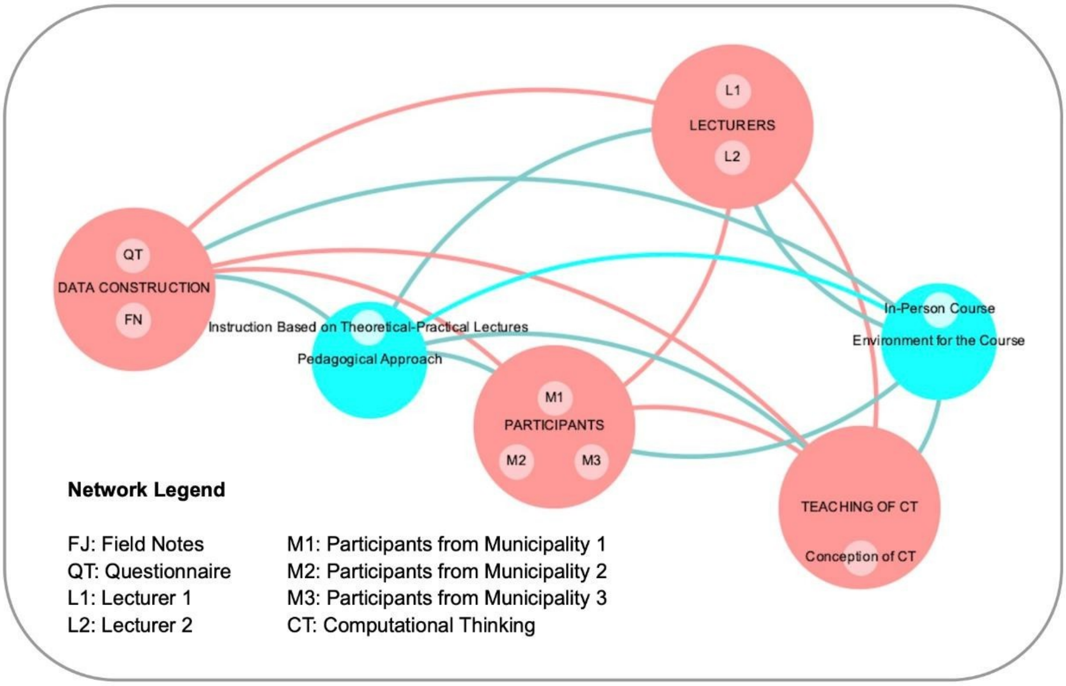
weakest connections between groups of intermediate actants to the translations between the formation of groups constituted by mediating actants, established throughout this *Moment* of the formative process.

Figure 1: Structure of the socio-technical network established during the analyzed *Moment,* based on the relationship between the different groupings formed and the respective connections and translations between the intermediate actants and mediators, respectively, that make up the groupings.



Source: Image by the authors (2024). Made from *Gephi* Software[8] and Paint S.

The established network highlights the connections between the formation of the different groups, made up of intermediate actants, represented by turquoise blue circles, and mediators, indicated by light red circles. The interactions between the formation of the intermediate actant groupings are demonstrated by continuous lines of light turquoise blue color, highlighting the intricate nature of these relationships. The unidirectional translations between the formation of the mediating actant groupings and the intermediate actant groupings are represented by dark turquoise blue lines. On the other hand, the strongest translations, whether unidirectional or bidirectional, that occur between the formation of groups of mediating actants and that have the potential to cause significant changes in the network, are highlighted by continuous lines of dark red color.

[8] The image was constructed only with illustrative intent, without attribution of statistical weight in relation to the size of the nodes (circles) and edges.

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The instruments used to construct the data form the grouping called "*Data Construction*", made up of actors with the potential to modify the network. The traces left by these actants, specifically the *Questionnaire 1* and the *Field Notes*, represent the main data sources used for the description of this *Moment*. In addition to these, the experience of the researchers developed during the course, represented by the "*Lecturers 1 and 2*", served as an additional source of information for the description of this stage. Both groupings "*Lecturers*" and "*Data Construction*", played central roles in the network, through translational interactions, acting as protagonists alongside two other groups of mediating actants, the "*Participants*" (composed of teachers from Municipalities 1, 2 and 3) and the "*Teaching Computational Thinking*", the central theme of the course alongside the teaching of science.

On the other hand, the formation of groups made up of intermediate actors, such as the "*Pedagogical Approach*", through the Instruction Based on Theoretical-Practical Lectures and the "*Environment of the Course (In-Person Course)*" although they left traces, they only established connections, without the ability to radically modify the structure of the socio-technical network formed during this stage under analysis.

By analyzing the dynamism and variety of the actors that make up the groupings formed in relation to the specific objective investigated in this *Moment*, it is observed that among the participants of the course, the conception for the expression "Describe what you mean by "Computational Thinking", comes from the actant *Questionnaire 1*, reveals in the teachers' answers a multiplicity of terms, which will be mentioned below.

Valuable information also resulted from the actant "*Field Notes"*, prepared by two members of the Extension Project. Through these data sources, I describe the moments between the beginning of the course and the presentation of the ICF, which preceded the completion of the *Questionnaire 1* by the professors participating in the course. It was also explained about the dynamics of the actions of continuing education offered by the Extension Project, as well as information about the Research Group in Science and Biology Education, at Unioeste, and its specificities, as described below:

> Lecturer 2 emphasized the importance of exchanging experiences and carrying out interventions to share knowledge with teachers. Lecturer 1 presented what will be addressed in each of the meetings. [...], the theme of his research and spoke about the importance of the participation of teachers in answering the questionnaires. He asked the participants, whenever possible, to portray the reality of their pedagogical practice so that we can understand the different realities. Lecturer 2 explained [...]

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> that the project went through the ethics committee [...] and the specificities of the ICF. (Field Note 1, 2023).

By examining the diversity of teachers that make up the grouping *Participants*, and the plurality of answers in relation to the specific objective investigated, the multiplicity of perceptions that the course participants have in relation to the question contained in the *Questionnaire 1* "*Describe what you mean by 'Computational Thinking'*".

It is important to note that in this specific group, enrollment in the training course was motivated by the interest of the teachers themselves. In this context, it was observed that four teachers were already working with the CT in the early years of elementary school in one of the municipalities participating in the training. I present, initially, the answers of these four participants, all professors of the *Municipality 3.*

These participants, in particular, demonstrated a better perception of the concept of CT, as evidenced. One of them described his understanding of CT as being: "Different ways of solving problems, which need to follow a methodology, or rather an order of commands forming a strategy" (Participant I, 2023). The answers of the other three teachers are presented below:

> Computational thinking is an ability to create strategies in the same way that a computer creates to solve situations, with or without the use of technologies (Participant F, 2023).
>
> We can point out that computational thinking is a necessary instance to solve a problem or reach a goal. The divisions of the computational CT it is possible to praise 4 pillars according to which are steps or aspects to be considered to solve the problem according to: abstraction, pattern recognition, decomposition, and the last pillar to be considered algorithms (Participant G, 2023).
>
> Computational thinking can be defined as a list of organized procedures used to define an action. To make it easier to understand, it is like a cake recipe that must be observed step by step to successfully reach the end of the recipe. Computational thinking has four fundamental pillars: abstraction, problem-solving, decomposition, and logical reasoning (Participant J, 2023).

In their answers, it is possible to observe several elements, usually found in the conceptual definitions of the literature on CT, such as: *Solve problems* or its variations (solving a problem, solving the problem, solving situations and solving problems), *strategy* and its plural (strategies) and *Organized procedures* (synonym for set of steps or by means of clear steps).

This finding can be evidenced from Brackmann's (2017) definition, which conceptualizes the CT as a facet that contemplates multiple human capacities, including critical and creative ones, which, through the fundamentals of computing, seek to identify and solve problems in different branches of knowledge, employing a set of coherent steps, so that both a person and a machine are able to perform it effectively.

The answers of Participants G and J mention the pillars of the CT. In general, the definitions in the literature do not directly allude to the pillars of the CT when describing its concept. In Participant J's response, he writes his perception of CT as being composed of four pillars "[...] *abstraction, problem-solving, decomposition, and logical reasoning*". In fact, the CT is made up of four pillars, which are: abstraction, decomposition, problem solving, and algorithm. Although logical reasoning was mentioned by the participant, it is not part of these pillars. This participant's answer reveals a confused understanding of his perception of the concept of CT. Although logical reasoning is a skill developed by CT, the concepts of CT in the literature generally do not explicitly describe the skills it helps to develop.

Logical reasoning corresponds to one of the cognitive skills included among the list of CT skills (GUARD; PINTO, 2021). In addition to this ability, Wing (2006) mentions analytical, investigative, communication and imagination skills. The issue of reasoning, in particular, has a deep connection with the process of problem solving (RIBEIRO; FOSS; CAVALHEIRO, 2019). According to Copi (1978, p. 20) "All reasoning is thought, but not all thinking is reasoning [...] There are many mental processes or types of thought that are distinct from reasoning", while "[...] logic is the study of the methods and principles used to distinguish correct from incorrect reasoning" (COPI, 1978, p. 19).

The fundamental purpose of logical reasoning is, essentially, to discover truths (RIBEIRO; FOSS; CAVALHEIRO, 2019). It comprises the structuring of thought according to norms of coherence of logic, so that a conclusion or the resolution of a problem is reached. In short, reasoning is a way of thinking and concluding, while logic is concerned with the rules and principles that govern this thought process (COPI, 1978).

According to Scolari, Bernardi and Cordenonsi (2007, p. 3), in the educational sphere "[...] it is necessary that logical reasoning be developed from the first stages, and Informatics, through educational games, can contribute in a motivating way to this". In the meantime, computational reasoning can be very useful, as it corresponds to:

> […] a generalization of logical reasoning: a process of transformation of inputs into output, where the inputs and output are not necessarily true sentences, but something (elements of any set), and the inputs and output do not even need to be of the same type, and the rules we can use are not necessarily the rules of logic, but some set of well-defined rules or instructions. In the same way that the product of logical reasoning is proof, the product of computational reasoning is the

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> sequence of rules that defines the transformation, which we commonly call algorithm (RIBEIRO; FOSS; CAVALHEIRO, 2019, p. 26).

Unlike mathematical logic, which focuses on propositions and their relationships, the focus of computation is on processes. Therefore, the result of the computational reasoning process must be a clear and unambiguous description of a procedure. In computing, models of these processes, also known as algorithms, are built. These algorithms can vary in terms of structure and complexity, and can be described in natural language, in specific languages, or as programs in a programming language (RIBEIRO; FOSS; CAVALHEIRO, 2019).

In summary, according to Ribeiro, Foss, and Cavalheiro (2019), logical reasoning is more general and abstract, while computational reasoning is a practical application aimed at solving problems through algorithms and computer programs. This difference occurs in the way the input must be structured, but especially the output of data and information. Computational reasoning requires, especially at the output, a structure in line with algorithmic thinking.

Therefore, on the CT, the output must take a structure defined through the algorithm or the thinking algorithm, which in turn can be represented in a descriptive way, through pseudocodes, flowcharts or lists of instructions that detail the step-by-step procedure to be followed to solve a specific problem. In logical reasoning, the output structure does not require a practical implementation and can be expressed through propositions, theorems, and proofs, focusing on the validity of the conclusions derived from given premises.

Returning to the specific objective in question, it is important to note that one of the participating teachers described in his answer an expression similar to: performed by human or machine agents. This participant also used the terms "plugged in" and "unplugged", as follows:

> I believe it is a way to understand the phenomena of the natural and artificial world, through a set of logical actions that build essential information for solving problems. Computational thinking can be articulated through a machine (Plugged) or by one or several human interactions through a game of chess (Unplugged) (Participant A, 2023).

This distinction highlights how diversified activities, whether plugged in or unplugged, allow the development of the CT, which can be driven by both people and machines. Therefore, the answer of this specific participant demonstrates his understanding of the breadth of possibilities by which the CT can be implemented in practice, whether with digital tools and devices or even without the use of these artifacts.

In this regard, the literature points out precisely these two ways as being the main approaches to work on the concepts and pillars of the CT. By the development of plugged-in activities, carried out with the use of a computer or equivalent equipment or by means of unplugged activities, carried out without the use of a computer or other digital means (BARROS; REATEGUI; TEIXEIRA, 2021). In addition to the possibility of working on these approaches in isolation, it is also possible to use mixed approaches, which bring together aspects of both (ASUNÇÃO *et al*., 2019; GREBOGY; SAINTS; CASTILHO, 2021).

Brackmann (2017) states that, even though educators and researchers are using the unplugged approach, the use of plugged activities represents the predominant methodology for teaching CT skills in schools. However, there are challenges to the use of this approach, especially with regard to the ability to provide adequate technological means and equipment. Therefore, it is necessary to expand knowledge related to activities unplugged and study the needs for CT development through this approach (TICON; MÓL; LEGEY, 2022).

The unplugged approach, also referred to in the literature as "unplugged computing", has been a common approach in many schools, especially in those that do not have adequate infrastructure, such as computers, internet connection, among others, or that have difficulties in providing such conditions (BRACKMANN, 2017). This approach has some advantages, including its ease of application in different contexts and situations, and in different economic and social realities. In this way, important computing topics can be taught without the need for computers, using unplugged computing.

Although teaching CT through unplugged activities represents an interesting alternative, there are doubts regarding its effectiveness. Brackmann (2017) notes that, while the effectiveness of using computers to promote the development of CT skills is widely studied, the unplugged approach does not receive the same attention in research. The author highlights that, although the use of unplugged activities is accepted by the scientific community, they are generally seen as complementary to plugged activities. In addition, the impact of unplugged activities on CT development is not yet fully understood, raising doubts about its effectiveness, especially when used in isolation.

On the other hand, the use of unplugged computing has been widely disseminated for teacher training. This is largely due to the ease of application, breadth of possibilities

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that can be implemented, in addition to facilitating understanding, since many of the teachers who are working at the moment did not have the opportunity to come into contact with this knowledge during initial training (BRACKMANN, 2017). In addition, a portion of these teachers have difficulties with aspects related to digital literacy. In this way, the unplugged approach contributes to increasing self-confidence and the acquisition of basic knowledge about the CT in a more enjoyable way for most teachers.

Among the answers of the other seven participants, it is possible to identify a variety of elements. These answers can be classified into two distinct groups. The first group includes answers that contain at least one element frequently found in the definitions of the literature on the concept of CT. These answers, although they present somewhat vague conceptions about the CT, nevertheless incorporate at least one central term or expression found in the definitions of the CT, such as "solving problems" or "performing an action":

> I see it as a way to use computational tools to solve practical day-to-day problems. As well as creating space for the development of students' ideas and creations (Participant N, 2023).
>
> The ability to act and reflect quickly or in a way that seeks to solve an action/reasoning without the use of a machine (calculator...), but with the cognitive capacity... Today machines solve many of the actions and daily/daily situations, so that we don't even know a cell phone number or a date of birth we remember, if not through equipment... (Participant S, 2023).

On the other hand, the other five answers, which make up the second group, are quite vague and sometimes confusing. Some of them bring elements "distant" from the central idea of what the CT is. This is the case of the following three answers: "Use of technological means in the classroom, improving the methodologies used by teachers, linking content to media practices" (Participant P, 2023). "When I read the sentence; it reminded me of computer programs; those little programs that are put // and letters!" (Participant H, 2023). "Mixing ideas together with computing. Creative games to interact with the student, but still very vague" (Participant M, 2023). The other two teachers in this second group also described answers that follow the same line of thought:

> I understand that it is the use of different information and communication technologies, as well as the use of digital technologies, in short, of ICT. I also reflect that the term focuses a lot on the use of the computer (Participant T, 2023).
>
> Curricular activities that use the computer, research activities based on digital platforms. Where it is possible for students to seek knowledge in a way with digital interaction" (Participant K, 2023).

Although the CT can be developed through digital platforms, such as Scratch, these answers, especially those of Participants P, T and K, contemplate aspects that are closer to the definition of digital literacy than to the definition of CT.

According to Ribeiro and Freitas (2012), digital literacy comprises a list of capacities, including the use of digital technologies for access, understanding, integration, communication and the creation of information in an ethical and efficient manner. Therefore, as can be evidenced, in the answers of these participants, they are more related to the definition of digital literacy than to the definition of CT.

Although there is no single and widely accepted definition in the literature to conceptualize the which is the CT, most authors describe it as a set of skills used in the search for solutions to problems in the various branches of knowledge, with the use of the fundamentals of computing, through a logical sequence of steps, which can be executed by agents humans or machines, to solve the problem (WING, 2006; ISTE; CSTA, 2011; BRACHMANN, 2017; ROSAS *et al.*, 2017; BNCC, 2018).

Although some of the participants showed a medium level of knowledge about the concept of CT, it was It is evident that most still associate it strictly with computing, computers and the use of digital technologies, thus presuming its application exclusively through plugged activities. Only one of the professors mentioned the possibility of developing it in a plugged and unplugged way, suggesting a more comprehensive and flexible view. On the other hand, there was one participant who defined it as being: "The ability to act and reflect quickly or in a way that seeks to solve an action/reasoning without the use of a machine [...]". Such an answer presupposes that the CT can be run exclusively by human beings, which demonstrates the lack of knowledge of the possibility of being worked in a plugged manner, through digital devices or even in an integrated way, mixing plugged in and unplugged computing.

In this specific context, we can establish a comparison by considering the data from our research and those from the research conducted by Beleti Junior and Sforni (2022). They investigated the perception of the term CT among basic education teachers, covering several areas of knowledge, with prevalence for teachers of human and social sciences. In this survey, just over 77% of the teachers answered that they do not know the term. Of the almost 23% who answered that they know the term, when they analyzed the explanation of these professors, they found:

> […] descriptions related to problem solving in ten of the answers, some including technologies or computers, totaling seven mentions of these words, followed by definitions that involve basic concepts of computing to analyze problems (3), programming (2) and logical reasoning (1) (Beleti Junior; Sforni, 2022, p. 148).

As we reflect on the results of Beleti Junior and Sforni (2022), It is possible to draw parallels with those of our research. Both studies share as one of the objectives to investigate how basic education teachers perceive CT. In addition, both point to similar trends, which demonstrate the need for more comprehensive and in-depth training initiatives. These training actions should provide conditions for teachers, regardless of the curricular area, to be able to incorporate the knowledge and skills associated with CT in their pedagogical practices.

In this regard, the CT, due to its flexibility and breadth, can be integrated into the various fields of knowledge, and therefore, it has been the object of several recent researches with the objective of understanding its definition, alternatives for how to insert it with different disciplines and ways to develop its potential in the teaching and learning processes (Beleti Junior; Sforni, 2022). However, there are still few and very recent training actions aimed at the implementation of CT in science teaching. This was even the main barrier reported by the teachers who participated in the training course, and which compromises a wider dissemination of the CT for the resolution of problems involving specific contents of science, biology as well as several other curricular components of basic education.

FINAL CONSIDERATIONS

Although computational thinking is a relatively new knowledge in the educational context, initiatives to integrate it into the various curricular components of basic education have attracted the attention of scholars. In our research, we used the Actor-Network Theory to analyze the perception of computational thinking in a group of participants formed mostly by science teachers from the public school system, who voluntarily enrolled in the training course "Computational Thinking in Science Teaching".

The results reveal that most participants were unaware of the concept of computational thinking, with the exception of some teachers who already applied it, although their answers were still partial. This fact contextualizes our data. In other words, if we were dealing with a differently formed group of teachers or conducting a broader

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survey of basic education teachers, we would probably find an even smaller number of teachers with perception of aspects related to computational thinking.

Thus, it is essential to expand training initiatives, enabling teachers not only to understand the fundamentals of computational thinking, but also to apply them creatively and effectively in the school environment. Strengthening this understanding among teachers will allow for a wider dissemination of this knowledge, enabling them to interpret the technological world and to apply this knowledge in scientific and social contexts, which in turn will reflect on their students and society at large.

ACKNOWLEDGMENTS

The authors would like to thank their colleagues from the Extension Project Teacher Training for the Teaching of Science and Biology and the Research Group on Education in Science and Biology (Gecibio), from Unioeste Cascavel, for their contribution.

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