Research, Society and Development, v. 12, n. 7, e18612742732, 2023
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v12i7.42732

Developing Computational Thinking in the City through an OnLIFE Education and Digital Citizenship perspective

Desenvolvendo o Pensamento Computacional na Cidade a partir de uma perspectiva de Educação OnLIFE e Cidadania Digital

Desarrollando el Pensamiento Computacional en la Ciudad a través de una perspectiva de Educación OnLIFE y Ciudadanía Digital

Received: 07/18/2023 | Revised: 07/25/2023 | Accepted: 08/01/2023 | Published: 08/02/2023

Janaína Menezes
ORCID: https://orcid.org/0000-0002-6789-6951
Universidade do Vale do Rio dos Sinos, Brazil
E-mail: janamenezes73@gmail.com
Eliane Schlemmer
ORCID: https://orcid.org/0000-0001-8264-3234
Universidade do Vale do Rio dos Sinos, Brazil
E-mail: elianeschlemmer@gmail.com
Massimo Di Felice
ORCID: https://orcid.org/0000-0002-6646-4321
Universidade de São Paulo, Brazil
E-mail: massimo.atopos@gmail.com

Abstract
Digital citizenship is about the citizenship of the algorithmic, datatified, connected, and sensorized world of metaverses, multiverses, big data, and artificial intelligence. It is the expression of a new type of architecture that promotes the emergence of a computational ecology made of people, data, algorithms, sensors, forests, weather, viruses, and cities. This connection challenges us to a new cognitive policy in the field of Education. The objective of the article is to discuss ways of knowing and producing knowledge related to the development of computational thinking in K-12 Education to understand how this language is promoted and produced in an immersion path in the city, understood as a territory of hybridizations. The experiences in the city are part of research conducted at the International Research Group on Digital Education, GPe-dU UNISINOS/CNPq, developed from inventive, sympoietic, interventionist, and gamified pedagogical practices. As a research method, it appropriates the intervention-research cartographic method for the production and analysis of data. The results presented are based on elements present in the reticular and connective epistemologies, in the theory of inventive cognition, and in the concepts of transorganic connective act, and atopic inhabitancy. The results indicate that computational thinking is being leveraged in the co-articulation between human and non-human entities, from a citizen OnLIFE Education perspective, contributing to its interdisciplinary and transversal understanding, as well as pointing to the emergence of an ecological cognitive policy in education.
Keywords: Computational thinking; New literacies; Education; Citizenship; Innovation; Critical thinking.

Resumo
A cidadania digital trata da cidadania do mundo algorítmico, datatificado, conectado e sensorizado de metaversos, multiversos, big data e inteligência artificial. É a expressão de um novo tipo de arquitetura que promove o surgimento de uma ecologia computacional feita de pessoas, dados, algoritmos, sensores, florestas, clima, vírus e cidades. Essa conexão nos desafia para uma nova política cognitiva no campo da Educação. O objetivo do artigo é discutir formas de conhecer e produzir conhecimento relacionadas ao desenvolvimento do pensamento computacional na Educação Básica para entender como essa linguagem é promovida e produzida em uma trajetória de imersão na cidade, entendida como território de hibridizações. As experiências na cidade são parte de pesquisa conduzida no Grupo de Pesquisa Internacional em Educação Digital, GPe-dU UNISINOS/CNPq, desenvolvidas a partir de práticas pedagógicas inventivas, simpoiéticas, intervencionistas e gamificadas. Como método de pesquisa, apropria-se do método cartográfico da pesquisa-intervenção para a produção e análise dos dados. Os resultados apresentados são baseados em elementos presentes nas epistemologias reticular e conectiva, na teoria da cognição inventiva, e nos conceitos de ato conectivo transorgânico e habitabilidade atópica. Os resultados indicam que o pensamento computacional está a ser potenciado na co-articulação entre entidades humanas e não humanas, numa perspectiva de educação OnLIFE cidadã, contribuindo para a sua compreensão interdisciplinar e transversal, bem como apontando para a emergência de uma política cognitiva ecológica em Educação.
Palavras-chave: Pensamento computacional; Novas literacias; Educação; Cidadania; Inovação; Pensamento crítico.

Resumen
La ciudadanía digital es la ciudadanía del mundo algorítmico, datatificado, conectado y sensorizado de metaversos, multiversos, big data e inteligencia artificial. Es la expresión de un nuevo tipo de arquitectura que potencia el surgimiento de una ecología computacional hecha de personas, datos, algoritmos, sensores, bosques, clima, virus, ciudades. Esta conexión nos desafía a una nueva política cognitiva en el campo de la Educación. El propósito del artículo es discutir formas de conocer y producir conocimientos relacionados con el desarrollo del pensamiento computacional en la Educación Básica para comprender cómo se potencia y produce ese lenguaje en un curso de inmersión en la ciudad, entendida como un territorio de hibridaciones. Las experiencias en la ciudad forman parte de investigaciones realizadas en el Grupo Internacional de Investigación en Educación Digital, GPe-dU UNISINOS/CNPq, desarrolladas a partir de prácticas pedagógicas inventivas, simpoiéticas, intervencionistas y gamificadas. Como método de investigación, se apropia del método cartográfico de intervención-investigación para la producción y análisis de datos. Los resultados presentados se basan en elementos presentes en las epistemologías reticular y conectiva, en la teoría de la cognición inventiva y en los conceptos de acto conectivo transorgánico y habitar atópico. Tales resultados indican que el pensamiento computacional está siendo apalancado en la co-articulación entre entidades humanas y no humanas, desde una perspectiva de Educación OnLIFE ciudadana, contribuyendo a su comprensión interdisciplinar y transversal, así como apuntando al surgimiento de una política cognitiva ecológica en educación.
Palabras clave: Pensamiento computacional; Nuevas alfabetizaciones; Educación; Ciudadanía; Innovación; Pensamiento crítico.

1. Introduction

In the last decades, the evolution of the web presented some peculiarities that evidenced its ecological potential and connective nature. This recent historical process is identified as a progressive process of expansion of networks and as an evolutionary increase in the forms of connectivity that, after people and computers (social networks), started to allow interaction in networks of things (IoT), biodiversity (sensors) and territories (geographic information systems).

The possibility of things, plants, buildings, and the most diverse types of surface, whether organic or inorganic, being able to issue information and produce content on the web, determined the creation of a new type of common and the advent of a new morphology of the social[1]. Through sensor networks, Big Data, and IoT flow, we can now see and hear changes in biodiversity, in climate change and measure and monitor, through automated Big Data processing, the impact of our development model on the planet. The importance of the last generations of networks for the construction of a new type of common, extended to non-humans, finds further confirmation in the recent pandemic and the particular type of interactions generated by it.

More than being based on forms of aggregation between humans and non-humans (Latour, 1994), the proposal of digital citizenship (Di Felice, 2021, 2022) expresses the transorganic quality of such networks that, rather than associating diverse entities, connect them from different perspectives, a process of interaction produced by the datafication process. Not only algorithms, but also Big Data, AI are, as actants, entities that intervene and that contribute to the realization of an emerging action in a network (Latour, 2012), but the morphology of the common starts to happen through an interaction data, software, platforms, and digital networks. In other words, the "nature" of our social has become processable and digitally dynamic by the informative specifics and the datafication process and, therefore, by the processing of interactions through data (Accoto, 2021).

The attribution of data and binary code to any type of surface proposes the abolition of the full and autonomous existence of things and their simultaneous transformation into equivalent serial numbers. In this sense, datafication, based on the alteration of all types of surfaces in data and on their automated connection, presents itself as a process of world

[1] [1] From the associative and reticular forms proposed by the Actor-Network Theory (ANT) by B. Latour, within the scope of the social sciences, to the philosophical debate on the active and interacting properties of matter (Perniola, 1994; Harman, 2018) and the one on protagonism of viruses (Haraway, 2016), to the debate on the intelligence of plants (Mancuso, 2017; Coccia, 2016) and that on multi naturalism proposed in anthropology by De Castro E. V. (2018), express the dimension of a "cosmopolitical communitarianism" " (Stengers, 2005) expression of an aggregative and material complexity.

transfiguration. We dwell in a new common, made not only of physical realities but also of data, a world of info-realities, materialities, biodiversity, and physical and connected surfaces, which connect and interact with each other in networks through a datafication process. Our common became an info-common, our communities, info-communities, and our social became composed of transorganic networks. Citizenship extends to new actors, the product of a process of connecting all things and of a process of changing reality in data and the automated processing of the same.

Digital citizenship is nowadays the scope of interdisciplinary research that focuses on overcoming the Western political project and the beginning of a new culture of governance in complex networks, characterized by interactions in architectures no longer composed of subject and object.

The interest in the development of computational thinking that we aim to discuss emerges from this inhabitancy, increasingly permeated by digital networks, in which human and non-human beings are in constant connectivity. Thus, developing it also implies understanding its dimension beyond the human or technologies, but as a possibility of establishing connections that are no longer limited, according to Di Felice (2017), to a network of information transmitted by the computer. It is another ecology also formed by the "informative role of things, rivers, forests, roads, algorithms" (Schlemmer, Di Felice, Serra, 2020, p. 5). Hence, the objective of this research carried out at the International Research Group on Digital Education, GPe-dU UNISINOS/CNPq, was to understand how computational thinking could be produced and leveraged through an immersion path in the hybrid city territory. Next, we will present the theoretical framework that guided the construction of this path and supported the pedagogical practices.

2. Theoretical Framework

The present time, increasingly connected, is imbricated in the evolution of artificial intelligence, robotics, the internet of things, wearable technologies, Big Data, and nanotechnology, among others, which allows us to say that we live in a hyperconnected reality.

This reality brought to the debate, within the scope of the scientific community and the technology industry, the importance and necessity of computational thinking development in education. Wing (2006), who inaugurated this debate in her first article mentioning the term 'computational thinking', stated that this is another fundamental literacy to act in the 21st century.

The process of digitalization and connectivity currently experienced makes it possible to establish connections beyond human and digital technologies. According to Schlemmer, Di Felice, and Serra (2020), not only humans and technologies inhabit networks, but also biodiversity, objects, surfaces, and data.

Wing's article in 2006, where computational thinking is presented as, mainly, the ability to solve problems, from the premises of computer science, but not limited to this area, caused a stir in the scientific community when published. However, this is not something new, since Papert (1971, 1980, 1994) had already, even not using this term, related computational thinking to "thinking by procedures" (procedural thinking). His research gave rise to the LOGO language and philosophy, developed in the late 1960s and popularized in the 1980s.

Wing (2006) states that computational thinking will be embedded in our lives as soon as words like "algorithm", for example, are appropriate in everyday language. But, for this, we understand that it is necessary to experience the process of creating, writing, and executing the language of an algorithm in different ways, in order to incorporate its meaning in fact in life, and thinking, according to Lopes (2010), beyond technique and utilitarianism, in the sense of invention and investigative conduct.

The literature review, based on the article by Wing (2006), made it possible to understand the conceptual scope of computational thinking, more broadly and openly. From 2006 to 2017, Wing revisited discussions of computational thinking

and modified this concept. It is highlighted that elements of computer science, including abstraction, decomposition, data representation, variables, recursion, debugging, and modeling are part of computational thinking, but it is not knowledge belonging only to computer science, since such elements are present, pervasive and transversal in other areas. Morin (2007, 2015), understands the thinking process in its complexity, attributing to it a dialogic, recursive, and hologrammatic form of expression. There is a dialogue between part and whole (it isolates itself to connect), in a process of recursion, where parts and effects turn to the whole, the whole feeds on the parts, and the essence of the whole is in each part.

From this debate in the scientific community, international documents discussed and aligned premises of computational thinking in education, including the ISTE (International Society for Technology in Education), CSTA (Computer Science Teacher Association), and NRC (National Research Council) in the United States, Royal Society and BCS-The Chartered Institute for IT in the United Kingdom. In Brazil, to insert the discussion on computational thinking in K-12 Education, documents organized by the SBC (Sociedade Brasileira de Computação) and CIEB (Curriculum of Reference in Technology and Computing) aimed to incorporate it into the Common National Base Curriculum-BNCC (Brazil, 2017). However, in the Brazilian education reality, the BNCC specifically brings the term computational thinking related to the development of competencies in mathematics in the final years preceding high school.

Computational thinking understood as an interdisciplinary or cross-curricular theme is mostly a consensus among researchers and international and national research societies. The nature of computational thinking provides opportunities to integrate it into all areas of education (Yadav; Hong; Stephenson, 2016). This premise is also endorsed by Barr, Harrison, and Conery (2011), Barr and Stephenson (2011), Bundy (2017), Estapa, Hutchison, and Nadolny (2017), Fletcher and Lu (2009), Guzdial (2008), Henderson (2009), Good, Keenan, Mishra (2016), Wing (2006, 2008, 2016, 2017). This understanding is addressed in the documents of the NRC (2010), ISTE/CSTA, (2011), Royal Society, (2012), SBC (2017), and CIEB (2018).

As stated by Di Felice (2022), we live in a world of algorithmization and this instigates in the educational field, to understand the transversality and interdisciplinarity of computational thinking as a language transcending the human, producing connections in constant movement, away from centralities and dualisms as subject-object, subject-technique, subject-environment. However, the culturally and socially recognized inhabitancy of teaching and learning still develops, according to Schlemmer et al (2021), predominantly in the physical, geographically located spaces of Formal Education institutions, heirs of directive pedagogies that develop from such dualisms, and in a pre-digital time. Understanding computational thinking as being developed in this new sensorial architecture where cognitive and relational ecologies are enhanced by digitality and connectivity are problematizations of the present time. This challenges us to think and build a new cognitive policy in education: how could computational thinking be leveraged beyond the school walls and inhabit the hybrid city territory?

The world/life algorithmization process problematizes the way of knowing and producing knowledge in a context of digitality and connectivity, where hybrid realities emerge. This leads to the understanding that the thinking of the present time is constituted with the digital, a "think with", which requires thinking co-engineered with different digital technologies in the network. According to Accoto (2020), the code "is designing and building the new way of being of our world, of our society, that is, the code operates transformations and redefines, ontogenetically, the conditions of possibilities of the world" (Accoto, 2020, p. 34). Therefore, it implies Education.

Computational thinking, the code – a language of our time, the different technologies that expand in the network: environments, platforms, applications, metaverses, games, wearables, intelligent agents, and the Internet of Things (IoT), have the power to create a new social sensorium, a "feeling" the world - Internet of Senses (IoS) through a "digital sixth sense", which complements the five traditional senses, as mentioned by Accoto (2020). They are new interaction architectures that potentiate new ways of inhabitancy. According to Di Felice (2021), it is no longer about being exposed to content nor just

interacting with the media that disseminate it. To communicate, interact and learn in these networks and platforms, it is necessary to inhabit them, experience them, becoming part of these ecosystems. But how are we appropriating this thinking, this language, this new sensorium to educate the generations so that they can understand, inscribe, and undertake intervening in this world in the perspective of operating social transformations?

This context, associated with the pandemic and climate change, highlights the role of non-humans and their power to interfere, modify and influence our interactions, our lives and, above all, our deliberative architectures. This challenges contemporary education, contributing to the emergence of an OnLIFE Citizenship Education (Schlemmer, 2020), which understands digital citizenship as something lived and experienced reticularly, through the continuous connectivity between humans and non-humans, in an ever-changing world, increasingly digitized and connected. Therefore, it is not an education "for" digital citizenship as if it were something external to us.

The concept of OnLIFE Education has been constituting the triad research-development-training in the International Research Group on Digital Education, GPe-dU UNISINOS/CNPq, based on the concept of Hybrid and Multimodal Education (Schlemmer, 2016), which subsidized the design and development of inventive methodologies and sympoietic, inventive and gamified pedagogical practices (Schlemmer, 2018), validated at different educational levels and contexts. This movement led to the concepts of the symbiote and learning while miscegenation, and invention, by Michel Serres, expanding inventive cognition (Kastrup, 2015); deepening the understanding of reticular and connective epistemologies, transorganic connective act, transubstantiation, and atopic inhabitancy (Di Felice, 2012, 2009, 2017); onlife society (Floridi, 2015); hyper complexity and sympoiesis (Haraway, 2016) and; Hyperobjects (Morton, 2013). These, associated with the challenges of thinking about education in a pandemic/post-pandemic world, potentiated the emergence of OnLIFE Education.

OnLIFE Education, where "On", means on, connected, and characterized as an education connected to "LIFE", which emerges and develops from problematizations of the present time/world, in a hyperconnected reality. It implies an inhabiting of teaching and learning that develops in transorganic connective acts (Di Felice, 2017), in a process of invention and transubstantiation of Education, in a citizenship perspective. It is a concept in motion, in a network of concepts-methodologies-practices relationships that emerge from reticular and connective epistemologies (Di Felice, 2012) and from the understanding of digital technologies as technologies of intelligence (Lèvy, 1996), which expand, externalize, and modify human cognitive functions and; as environmental forces (Floridi, 2015), which problematize who we are, how we relate to each other, the perception we have of the world, and the way we interact with it.

From this perspective, such technologies and communication networks are no longer understood as tools/instruments/resources/support/means to be used in education, in a transposition perspective, and become appropriate in creation/co-creation processes, once the human, by acting with them, invents himself and the world, in an ecology of intelligence. The OnLIFE Education paradigm thus, implies an epistemological turn, a new cognitive policy in education, where teaching and learning processes are structured in networks to be inhabited, constituting a new educational ecosystem. This challenges us to build new connective-ecological-ecosystemic pedagogies to overcome a theory of action, inherited from an anthropocentric/subject-centric/dualist worldview. Pedagogies that allow us to develop teaching that is also OnLIFE, understanding this new sensorial architecture and the cognitive and relational ecologies that current generations are developing. Next, the OnLIFE Citizenship Education experiment which enhances computational thinking being leveraged in the city, will be reported.

3. Methodology - Developing computational thinking in the city: an OnLIFE Citizenship Education experience

The OnLIFE Citizen Education experiment that will be presented and discussed, aims to understand how computational thinking develops and is strengthened in co-engendering with the city. The city, in this article, goes beyond its physical geography and is a complex, agent, and communicative entity, inhabited by humans and non-humans that connect and communicate through the Internet of Things (IoT), sensors, wearables, algorithms, and Big Data. From these info architectures emerges a cybrid space (Schlemmer et al, 2020), permeated by digital networks transforming the city into information and making us rethink the idea of communication. This space, called by Schlemmer et al (2020) as cibricity, results from this hybridization of a physical city, geographically located, with a digital city, which expands in information through connectivity, constituting transorganic networks (Di Felice 2009, 2012).

This experience shows the development of computational thinking (Wing, 2006, 2008, 2016, 2017), (Papert 1971, 1980, 1994), (Csizmadia et al, 2015), (SBC, 2017), (CIEB, 2018) and, in particular, the path towards understanding and building the language of an algorithm linked to the city territory. It articulates from a theoretical-epistemological perspective the hybridization of urban and post-urban spaces (La Rocca 2016, 2018), (Di Felice 2009, 2012, 2017, 2022), inventive cognition (Kastrup 2001, 2010, 2015), gamified learning projects (Schlemmer 2018) and OnLIFE Education (Schlemmer and Moreira, 2020), (Schlemmer, 2021).

It is qualitative research, developed from the cartographic method of research intervention according to Passos, Kastrup, and Escóssia (2015); Passos, Kastrup, and Tedesco (2016), and Kastrup (2019). Unlike other methods of investigation, in which the researcher keeps away and seeks to isolate the object of study, in cartography the researcher inhabits the territory being investigated, focused on the production of data, analysis, and intervention, since the research process brings out realities that were not given, waiting for an observation. As research instruments, photo records, audio and video recordings transcripts, interviews, and a field diary were used.

Cartography is guided by clues and not by rules to be applied, since, as it follows processes, it could not have, in advance, a totality of methodological procedures. The clues guide the researcher-cartographer as a reference for walking along the research path itself. Attention functioning (Kastrup 2019), is an important clue in the formation of the researcher-cartographer, defined as open and concentrated, and having four movements: tracking, touch, landing, and attentive recognition. This clue is related to attention functioning during fieldwork, understanding the field that ranges from the researcher's first concerns to the immersion in the investigation territory.

It has been present in our research group (GPe-dU UNISINOS CNPq) from two perspectives: as a research method and as a method that enables the production of new learning methodologies and pedagogical practices. The inhabited territory was K-12 Education, more specifically, two classes of Elementary School. It covered 39 students from 8 to 10 years old, from a Bilingual Education School (Portuguese-English), in the city of Novo Hamburgo, Rio Grande do Sul, Brazil, throughout the period between 2019 and 2022 (before, during, and after the Covid-19 pandemic).

The studies in Human Sciences during the school year were about the city, according to BNCC (Brasil, 2017). They referred to memory spaces, social and cultural diversities, the development of geographic, historical, and spatial analysis of perceived, conceived, and lived spaces, cartographic languages, different textual genres, and digital technologies. The school is located in the Historic Center of Hamburgo Velho and was the first school founded in the city, therefore, part of its cultural heritage and buildings are in the heritage zone. The experiment aimed at bringing the interdisciplinary and transversality of computational thinking to the field of Human Sciences, given that in the curriculum, there was a curricular component called Programming on the *code.org* platform.

The research was developed in a hybrid context, with regard, according to Schlemmer (2016), to the presence,

technologies, space, time, languages, and cultures, articulated to the need to understand the teaching and learning processes in contexts of multimodality, mobility, pervasiveness, ubiquity, and gamified learning, in the production of an atopic dwelling (Di Felice, 2009). In this citizenship experience, the four movements of the cartographer's attention took place from the exploration of the city (tracking); what drew attention to the city's experiences (touch); the networks of strength and connection that emerged as clues in the development of computational thinking (landing); the gamified learning projects, enhancers of computational thinking and construction of algorithms (attentive recognition). In the following section, the results will be discussed through the perspectives proposed in this article.

4. Results and Discussion

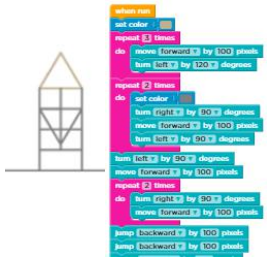
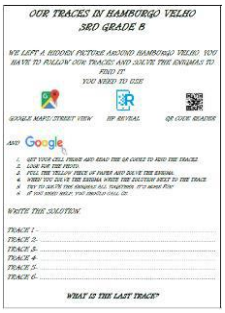
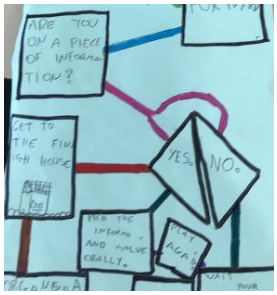
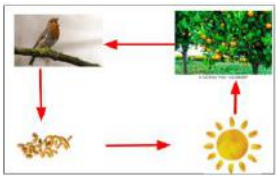
The experiment will be discussed concerning students' understanding and writing of an algorithm through the following perspectives: the hybridization of the physical, biological, and digital world; the production of an inventive path; the transorganic connective act, transubstantiation, and atopic inhabitancy; and the perspective of digital citizenship in OnLIFE Education.

4.1 Regarding the hybridization of the physical, biological, and digital world

It was possible to understand the computing activity occurring in flow, favoring the construction of the understanding of the algorithm in the hybridization of the physical, biological, and digital worlds. The movement in different physical, geographic, and/or digital Spaces in the city led to different experiences. The space in the Hamburgo Velho neighborhood, where the activities predominated, raised curiosity about the preservation of historical and cultural heritage, architecture, the relationship between frugivorous birds and trees, the residents who lived in the old buildings, the history of the arrival of the first immigrants and the social diversity awareness. Such experiences were built from the different inhabited spaces, transcending the idea of physical and geographic territory and, therefore, also producing another meaning for inhabitancy: atopic inhabitancy. This inhabitability was produced by the hybridization of physical and digital spaces and allowed us to understand computational thinking in connection to non-humans.

The notion of the algorithm and its writing was developed in the co-engineering of human and non-human entities that inhabit these spaces, expanding and producing a more ecosystemic vision of the city, articulated in terms of art, architecture, biodiversity, physical and digital space, and technologies. The experiences in the city gave rise to computing activity, paving the way for understanding how to produce algorithms based on procedural thinking and debugging (Papert, 1971, 1980, 1994). Through these movements, the experiences of gamified learning projects produced assemblages (Deleuze, 2000) between computational thinking, the city, and students. Assemblages in the sense of direct communication between them, between flows, made it possible for students to arrive at the thinking process which led to the construction of their algorithms. The table below shows the algorithms that were built on the experiences lived in the city involving the following areas and languages that will be discussed afterward.

Table 1 - Algorithms in the City.

The Fachwerk Algorithm	**The Traces in Hamburgo Velho Algorithm**	**The Gamebook Algorithm**	**TheNature Algorithm**
Students built timbered houses (a type of architecture found in historical landmarks in the city)	Students built a gamified path involving the city landmarks filled with enigmas that told its history.	Students built their games to share their experiences in the city.	Students represented the recursive relationship between frugivorous birds and tres
Block Language (code.org)	Narrative description	Flow Diagram	Flow Diagram
			

Source: Authors.

The **Fachwerk Algorithm** involved the building of the algorithm on the code.org platform, to perform the construction of half-timbered houses, an architectural technique found in the Historic Center of the city. Students were able to build notions of plane geometry and angles, and program algorithms related to learning about the city's architecture. The **Traces in Hamburgo Velho Algorithm** was built in the form of text, to develop a hybrid path in terms of physical and digital space, permeated by enigmas and clues about the history of the city, including the main tourist attractions visited. The **Gamebook Algorithm** was part of the construction of gamified stories, invented by the students, involving the different experiences in the city. These were transformed into a gamebook, where the mechanics and dynamics of those games were converted into a flowchart algorithm created by the students involving different technologies. The **Nature Algorithm** emerged from experiences during the Covid-19 pandemic, where the space of the city was resized even more from digital platforms, including Google Earth. This algorithm was built from the interaction between students, birds, and trees from the main city park on the platform. From inhabiting networks, in which information was exchanged not only between humans but with the entire context of the park, another notion of the algorithm was built, one that transcended its construction by humans.

In the experiences lived in the city, therefore, it was possible to understand the hybridization of the biological, physical, and digital world that compose the city, enhancing the development of computational thinking regarding the understanding of the algorithm.

4.2 Regarding the production of an inventive path

This understanding took place in the problematization experiences (Kastrup, 2001, 2010, 2015) that emerged from the context of the city, thus expanding the concept of cognition, as the invention of new and unpredictable problems. Inventive learning helps us to think about the present, and the world in the process of accelerated transformation. The experience was generated in the problematizations, in the co-engendering between human and non-human entities, in the encounter with what forces one to think, but which is not predetermined by rules to be followed. The dimension of cognition was expanded from the perspective of invention, concerning not encapsulating knowledge within rules determined by the curriculum or age. There was a process construction path, not information processing, so a permanent transformation was experienced during pedagogical

practices in the city. The experiences, once opened, brought problematization and the emergence of bugs. Whether it was the questions about the historical heritage, the programming of the half-timbered houses, or the "part by part" thinking process to assemble its algorithm, there was no predetermined path to follow, so the experience of problematization was lived with attention to its duration

It led to an embodied experience generating a relationship of belonging to the city, an ecological vision of what and who inhabits this space, another correspondence with time and attention in learning, and, above all, authorship in terms of treading the path to produce and write their algorithms, envisioning itself in process and product.

4.3 Regarding the transorganic connective act, transubstantiation, and atopic inhabitancy

When we talk about network connections that happen in an info digital architecture, Di Felice (2017) calls it a transorganic connective act. This connective act, described by the author, is produced by the ecosystemic interactions of diverse actants and interactants, human and non-human, and therefore transorganic. When entering into a correspondence of connectivity, it expresses its impermanent and creative dimension (an unpredictable and unrepeatable act), which opposes the anthropocentric, subject-centric, and dualistic perspective present in teaching.

This OnLIFE Citizenship experience did not establish differences between the physical geographic and digital contexts, since it emerged in a hybrid way in terms of spaces, presences, times, languages, and technologies (Schlemmer, 2016,) provided by connectivity and networks that were built in these different ways of dwelling.

The experience revealed discoveries in the city, and according to La Rocca (2018), it produced connections in which students could be (p. 217), "plugged in at the same time to each other and the space", without a double vision or a separation between physical and digital space. The hybridization of the physical, biological, and digital world allowed a type of inhabitancy constituted by communicative and interaction flows. It led students to know the city spaces and to understand, for example, through the Nature Algorithm, how the biodiversity at the main park organized itself and produced its procedures, that is, their computing activity. Human entities were not outside, carrying out a study, but inhabiting these networks in an encounter with non-human entities, without being separated or placed in opposition.

The computational thinking understanding, in addition to something created by humans, was produced in this connection, in this connective act conceived by Di Felice (2009, 2012, 2017), which occurred between human and non-human entities, being, therefore of a transorganic nature.

4.4 Regarding digital citizenship through OnLIFE Education perspective

The experiences in the city brought problematizations connected with life, methodologies, and pedagogical practices tensioned by the hybridization of times, spaces, technologies, presences, languages, and culture. Furthermore, they enabled the search for overcoming dichotomies (subject-object, individual-environment), and centralities (sometimes in the teacher, content, or the student). In addition, the interdisciplinary and transversal character of computational thinking, along with the perspective of problem invention, could emerge. The gamified learning projects (Schlemmer, 2018) proposed narratives with characters, missions, and puzzles, bringing a relevant aspect to thinking about the role of games in school. Games already bring themselves a computing activity because they imply analysis, patterns, abstractions, sequences, and conditions, among many other operations. In the learning projects experienced, paths were transformed and written into algorithms, and different ways of knowing and interpreting the city, both as a city of atoms and a city of bits, were developed.

The students established an understanding of the term algorithm through their experiences in the city, understanding it as a series of steps that are part of city life, and their own. From excerpts extracted in the interviews, such as "the city is a code of life", "an algorithm can help me in the sequence of my day", "the bugs were not bad, they helped us to think about the

algorithm", "we can have more than one algorithm to go from one place to the other in the city, so we can compare and decide which one is better", and "our life is an algorithm too", show that understanding the algorithmic language and how it guides and modifies our life is a matter of digital citizenship.

The experiences that emerged led to the understanding that computing is a way of communicating, living, knowing, and producing realities. They also led to the conception that the city's territory is resized, communicates, and is hybridized, where humans are members of an ecosystem that connects many algorithms. That enables a profound transformation in our inhabitancy conditions and citizenship interpretations. The comprehension of computational thinking potentiated in and with the city resulted from embracing a cognitive policy attentive to the path, invented while lived.

5. Conclusion

The culture of networks and connectivity makes us understand that we are part of an ecosystem, dots in a complex network, where each member is connected and depends on the others. A network that connects the extended social in the presence of biological, physical, and digital entities, producing transorganic connective acts in the weaving of these networks. From the objective established in this article, computational thinking emerged and developed with and in the city, from an inventive learning perspective, co-engendering human and non-human entities in an OnLIFE Citizenship Education experience. This process expanded the understanding of computational thinking beyond programming, where different experiences of writing algorithms were lived as well as the city, which transcended its geographical limits of a physical territory, enhancing itself as a living, complex, and communicative entity in the digital world.

This allows us to move in a direction to understand education in this network movement, demanding differentiated methodologies and practices. Hence, it is necessary to problematize the current cognitive policy, overcome directive pedagogies developed from the subject-object (S-O) binomial, along with discussing the platforming of education. The standardization and massification of content-centered teaching in digital apostilles, teaching systems where everything is previously defined, the reduction of teaching to platforms applications, and students to task performers for which the results are also already defined, represent the antithesis of OnLIFE Education.

Thus, problematizations emerge that stress future research aimed at understanding computational thinking in an interdisciplinary and transversal way, followed by methodologies that enhance invention, as well as future studies with regard to the development of K-12 teachers who work in this context. In the same way that OnLIFE Education understands digital technologies beyond tools, resources, or support, we need to understand and encourage more research on computational thinking through this perspective, transcending the limits of programming environments and the limits of K-12 institutions, modifying, hence, teaching and learning processes.

OnLIFE Education establishes a new cognitive policy, based on Reticular and Connective Epistemologies. This understanding changes the way of teaching and learning, leading to an inflow movement through the problematization of the present world in a connective, ecosystemic, sympoietic perspective, atopic inhabitancy, producing knowledge with everyone who inhabits these networks and potentiating new ways of narrating the world.

Acknowledgments

CAPES, CNPq, FAPERGS, FAPESP, Fundação Carlos Chagas, Itaú Social

References

Accoto, C. (2021). *O mundo dado: cinco breves lições de filosofia digital*. Paulus Editora.

Barr, D., Harrison, J., & Conery, L. (2011). Computational thinking: A digital age skill for everyone. *Learning & Leading with Technology*, 38(6), 20-23. https://bit.ly/3LuMnne

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? *Acm Inroads*, 2(1), 48-54. https://doi.org/10.1145/1929887.1929905

Baudrillard J.(1991). Simulacros e simulação. Relógio d'água

Brasil, M. E. C. (2017). Base nacional comum curricular. Brasília-DF: MEC, Secretaria de Educação Básica. https://bit.ly/38AijJH

Bundy, A. (2007). Computational thinking is pervasive. *Journal of Scientific and Practical Computing*, 1(2), 67-69. https://bit.ly/3sPUHaz

CIEB (2018). Currículo de referência em tecnologia e computação. http://curriculo.cieb.net.br/currículo

Coccia, E. (2018). La vie des plantes: une métaphysique du mélange. Éditions Rivages.

Csizmadia, A., Curzon, P., Dorling, M., Humphreys, S., Ng, T., Selby, C., & Woollard, J. (2015). *Computational thinking-A guide for teachers*. https://bit.ly/3luH3pm

CSTA, ISTE. (2015). *Computational Thinking Teacher Resource*. https://www.csteachers.org/.

Deleuze, G. (2000). *Mil platôs: capitalismo e esquizofrenia, vol. 5*. Editora 34.

De Castro, E. V. (2018). *Perspectivismo e multinaturalismo na América indígena*. Ubu Editora LTDA-ME.

Di Felice, M. (2009). *Paisagens pós-urbanas: o fim da experiência urbana e as formas comunicativas do habitar*. Annablume.

Di Felice, M. (2012). Redes sociais digitais, epistemologias reticulares e a crise do antropomorfismo social. *Revista USP*, (92), 6-19. https://doi.org/10.11606/issn.2316-9036.v0i92p6-19

Di Felice, M. (2017). *Net-ativismo: da ação social para o ato conectivo*. Pia Sociedade de São Paulo-Editora Paulus.

Di Felice, M. (2022). Digital citizenship and the end of an idea of world. Journal of e-Learning and Knowledge Society, 18(3), 22-28. https://doi.org/10.20368/1971-8829/1135816

Estapa, A., Hutchison, A., & Nadolny, L. (2017). Recommendations to support computational thinking in the elementary classroom. *Technology and Engineering Teacher*, 77(4), 25-29. https://bit.ly/3yVdQf8

Fletcher, G. H., & Lu, J. J. (2009). Education Human computing skills: rethinking the K-12 experience. *Communications of the ACM*, 52(2), 23-25. http://doi.acm.org/10.1145/1461928.1461938

Floridi, L. (2015). The onlife manifesto: Being human in a hyperconnected era (p. 264). *Springer Nature*.https://bit.ly/39z99NF

Good, J., Keenan, S., & Mishra, P. (2016, March). Education:= coding+ aesthetics; Aesthetic understanding, computer science education, and computational thinking. In *Society for Information Technology & Teacher Education International Conference* (pp. 91-98). Association for the Advancement of Computing in Education (AACE). https://bit.ly/3LuONSQ

Guzdial, M. (2008). Education paving the way for computational thinking. *Communications of the ACM*, 51(8), 25-27. https://doi.org/10.1145/1378704.1378713

Haraway, D. (2016). Antropoceno, capitaloceno, plantationoceno, chthuluceno: fazendo parentes. ClimaCom, ano, 3, 139-148.https://bit.ly/3FXKIW4

Harman, G. (2018). *Object-oriented ontology: A new theory of everything*. Penguin UK.

Henderson, P. B. (2009). Ubiquitous computational thinking. *Computer*, 42(10), 100-102. https://doi.org/10.1109/MC.2009.334

Kastrup, V. (2001). Aprendizagem, arte e invenção. *Psicologia em estudo*, 6, 17-27. https://bit.ly/3PMQzST

Kastrup, V. (2010). Experiência estética para uma aprendizagem inventiva: notas sobre o acesso de pessoas cegas a museus. *Informática na educação: teoria & prática*, 13(2). https://doi.org/10.22456/1982-1654.12463

Kastrup, V. (2015). A cognição contemporânea e a aprendizagem inventiva. In: Kastrup, V., Tedesco, S., & Passos, E. *Políticas da cognição*. Porto Alegre: Sulina.

Kastrup, V. (2019). The operation of attention in the work of the cartographer. *Multitudes*, 75, 125-134. https://bit.ly/3lOMu63

Latour, B. (1994). *Jamais fomos modernos*. Editora 34.

Latour, B. (2012). *Reagregando o social: uma introdução à teoria do ator-rede*. Salvador: Edufba.

La Rocca, F. (2016). Territórios híbridos: conectividade e experiências comunicativas tecnometropolitanas. *Revista FAMECOS: mídia, cultura e tecnologia*, 23(3). http://dx.doi.org/10.15448/1980-3729.2016.3.24817

La Rocca, F. (2018). *A cidade em todas as suas formas*. Porto Alegre: Sulina.

Lévy, P. (1993). *As tecnologias da inteligência*. Editora 34.

Lopes, D. D. Q. (2010). *Brincando com robôs: desenhando problemas e inventando porquês*. Santa Cruz do Sul, Brasil: EDIUNISC, 46.

Mancuso, S. (2017). *Plant revolution*. Giunti, Firenze.

Morin, E. (2007). *Introdução ao pensamento complexo* (Vol. 3). Sulina.

Morin, E. (2015). *O método 3: conhecimento do conhecimento*. Sulina.

Morton, T. (2013). *Hyperobjects: philosophy and ecology after the end of the world*. U of Minnesota Press.

National Research Council. (2010). *Report of a workshop on the scope and nature of computational thinking*. National Academies Press.

Papert, S., Solomon, C., Soloway, E., & Spohrer, J. C. (1971). Twenty things to do with a computer. Studying the novice programmer, 3-28. https://bit.ly/3wIx6cZ

Papert, S. (1980). *Logo: Computadores e educaão*. São Paulo: Brasiliense.

Papert, S. (1994). *A máquina das crianças*. Porto Alegre: Artmed, 17.

Passos, E., Kastrup, V., Escóssia, L. D. (2015). Pistas do método da cartografia: pesquisa-intervenção e produção de subjetividade. Sulina

Passos, E., Kastrup, V., & Tedesco, S. (2016). *Pistas do método da cartografia: a experiência da pesquisa e o plano comum*. Sulina

Perniola, M. (2005). *Sex appeal do inorgânico, O–Coleção Atopos.* Studio Nobel.

Royal Society (Great Britain). (2012). *Shut down or restart?: The way forward for computing in UK schools*. Royal Society. https://bit.ly/3wJwxkJ

SBC (2019). *Diretrizes para ensino de computação na educação básica*. https://bit.ly/3MAyDIN

Schlemmer, E. (2016). Hibridismo, multimodalidade e nomadismo: codeterminação e coexistência para uma educação em contexto de ubiquidade. *Educação a distância, qualidade e convergências: sujeitos, conhecimentos, práticas e tecnologias*. EdUFSCar, 1, 61-85.

Schlemmer, E. (2018). Projetos de aprendizagem gamificados: uma metodologia inventiva para a educação na cultura híbrida e multimodal. *Momento-diálogos em educação*, 27(1), 42-69. https://doi.org/10.14295/momento.v27i1.7801

Schlemmer, E. (2021). Educação OnLIFE: conceito e paradigmas. *Revista Educatrix*, 21, 45-51. https://bit.ly/3NrogXP

Schlemmer, E., Backes, L., Bittencourt, J., & Palagi, A. (2021). *O habitar do ensinar e do aprender onlife: vivências na educação contemporânea*. São Leopoldo, RS: Casa Leiria.https://bit.ly/3wsZwJq

Schlemmer, E., Felice, M. D., & Serra, I. M. R. D. S. (2020). Educação OnLIFE: a dimensão ecológica das arquiteturas digitais de aprendizagem. *Educar em Revista*, 36. https://doi.org/10.1590/0104-4060.76120

Schlemmer, E., & Moreira, J. A. M. (2020). Ampliando conceitos para o paradigma de educação digital OnLIFE. *Interacções*, 16(55), 103-122. https://doi.org/10.25755/int.21039

Schlemmer, E., Oliveira, L. C., & Menezes, J. (2021). O habitar do ensinar e do aprender em tempos de pandemia e a virtualidade de uma educação OnLIFE. *Práxis Educacional*, 17(45), 1-25. https://doi.org/10.22481/praxisedu.v17i45.8339

Stengers, I. (2005). *Cosmopolitiche*. Roma: Sossella.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33-35. https://doi.org/10.1145/1118178.1118215

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 366(1881), 3717-3725. https://doi.org/10.1098/rsta.2008.0118

Wing, J. M., & Stanzione, D. (2016). Progress in computational thinking, and expanding the HPC community. *Communications of the ACM*, 59(7), 10-11. https://doi.org/10.1145/2933410

Wing, J. (2017). Computational thinking influence on research and education for all. *Italian Journal of Educational Technology*, 25(2), 7-14. https://bit.ly/3wzUkU1

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: Pedagogical approaches to embedding 21st-century problem-solving in K-12 classrooms. TechTrends, 60(6), 565-568. https://doi.org/10.1007/s11528-016-0087-7