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Computational Thinking In The Cibricity: Experiences In Onlife Education

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Understanding the city as a living, complex and communicative entity moves away from an anthropocentric worldview, establishing other forms of communication, dwelling, and learning. This article presents a gamebook's development and building process that shows how computational thinking is leveraged and produced in immersion in cibricity (hybridization between a physical city, geographically located, with a digital city). The objective is to present how the co-engendering between the various entities that make up the city can enhance computational thinking from the perspective of inventive learning in an OnLIFE Education proposal. This practice comes from a doctoral thesis within the research project scope “THE CITY AS A LEARNING SPACE: Innovative pedagogical practices for the promotion of citizenship and sustainable social development”, financed by Fundação Carlos Chagas and Itaú Social, developed by Digital Education Research Group - GPe-dU UNISINOS/CNPq. It uses the cartographic method of intervention research to produce and analyze data. The results presented are based on elements in reticular and connective epistemologies, in the theory of inventive cognition, and the concepts of transorganic connective act, and atopic inhabiting. Such results indicate that computational thinking is being potentiated in the co-engineering between human and non-human entities, from the perspective of OnLIFE Education, contributing to its interdisciplinary and transversal understanding, as well as pointing to the emergence of an ecological cognitive policy in education.

Mots-clefs :
Computational Thinking, City, Cibricity, Heritage Education, OnLIFE Education

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INTRODUCTION

Experiencing the city, as a learning space, implies understanding it in the intertwining of its various times, and spaces, as well as, its social, historical, economic, and human and non-human dimensions. According to La Rocca (2018), exploring the city is an adventure of discovering and understanding, looking and observing, provoking a total immersion, since, as a container of life, it offers us an incomparable wealth of stimuli.

Environment and territory should not be understood as things, but, according to Di Felice[1], as something alive, a complex and communicative entity, providing learning and teaching that can also extend beyond the walls of institutions and classroom walls.

This understanding provides the vision of a network dialogue with different entities, such as biological, physical, or digital, that is, the recognition of the city inhabited by human and non-human entities. In these networks, digital technologies expand the presence in the city and establish other forms of dwelling and communication, in which humans and non-humans connect and communicate through the Internet of Things (IoT), sensing, wearables, and algorithms. From these info architectures emerges a cybrid space[i], permeated by digital networks, transforming the city into information and making us rethink the idea of communication. According to Schlemmer *et al*[ii], the cibricity results from this hybridization of a physical city, geographically located, with a digital city, which expands in information through connectivity, constituting trans-organic networks[iii].

In this context, we see the evolution of artificial intelligence, robotics, the internet of things, wearable technologies, Big Data, and nanotechnology, among others. This modifies the present time, making it increasingly connected, which allows us to say that we live in a hyperconnected reality in which it no longer makes sense to separate "online" from "offline". According to Floridi[iv], we live in an "onlife" society, where digital technologies are not "outside" of us, nor are they subject to total human control, such as Artificial Intelligence technologies. This understanding, according to Moreira and Schlemmer[v] makes it possible to "think/design different investigative, development and training contexts, which instigate inventiveness in the context of teaching and learning", since inhabiting and cohabiting is increasingly atopic, that is, beyond

geographic spaces.

Thus, the interest in computational thinking development, in this article, emerges from this dwelling, increasingly permeated by these digital networks, in which humans and non-humans are in constant connectivity. Developing it also implies understanding its dimension beyond the human or technologies, but as a possibility to establish connections that are no longer limited, according to Di Felice[vi], to a network of information transmitted by the computer. It is another ecology also formed by the informative protagonism of things, rivers, forests, roads, and algorithms[vii].

COMPUTATIONAL THINKING AND INVENTIVE COGNITION

The present time, increasingly hyperconnected, has 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[viii], when referring to computational thinking, stated that this is another fundamental literacy to act in the 21st century and presents it as, mainly, the ability to solve problems, from the premises of computer science, but not limited to this area. However, this is not something new, since Papert[ix] had already, even not using this term, related computational thinking to “procedural thinking”. His research gave rise to the LOGO language and philosophy, developed in the late 1960s and popularized in the 1980s.

Wing[x] states that computational thinking will be embedded in our lives when words like “algorithm”, for example, are appropriated in everyday language. Hence, we understand that it is necessary to experience the process of creation and execution of an algorithm in different ways, to incorporate its meaning in fact in life, thinking, according to Lopes[xi], beyond the technique and utilitarianism, in the sense of invention and investigative conduct.

A literature review, based on the article by Wing[xii], made it possible to understand, more broadly and openly, the conceptual scope of computational thinking. From 2006 to 2017, Wing revisited discussions about computational thinking and modified this concept, highlighting that elements of computer science, including abstraction, decomposition, data representation, variables, recursion, debugging, and modeling make part of computational thinking. However, it is not a knowledge that belongs only to computer science, since such elements are present, pervasive, and transversal in other areas according to the author.

International documents discussed and aligned premises of computational thinking in education, including 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 UK. In Brazil, to insert the discussion on computational thinking in K-12 Education, documents prepared by the SBC (Brazilian Computing Society) and CIEB (Curriculum of Reference in Technology and Computing) aimed to incorporate it into the National Common Base Curriculum-BNCC (Brasil, 2017). However, in the Brazilian education reality, the BNCC specifically brings the term computational thinking concerning the development of competencies in the area of mathematics in the final years of elementary school.

The understanding of computational thinking as an interdisciplinary or cross-curricular theme is practically a consensus among researchers and international research societies. It is argued that the nature of computational thinking provides opportunities to integrate it into all areas of K-12 education[xiii]. This premise is also endorsed in the articles by Barr, Harrison, and Conery[xiv], Barr and Stephenson[xv], Bundy[xvi], Estapa, Hutchison, and Nadolny[xvii], Fletcher and Lu[xviii], Guzdial[xix], Henderson[xx], Good, Keenan, Mishra[xxi], Wing . This understanding is addressed in the documents by NRC (2010), CSTA/ISTE, (2011), Royal Society, (2012), SBC (2017), and CIEB (2018).

As stated by Di Felice[xxii], we live in times of world algorithmization. This instigates us, in the educational field, to understand the transversality and interdisciplinarity of computational thinking in problematizations, in a network, transcending the human, producing connections in constant movement, away from centralities and dualisms as subject-object, subject-technique, subject -environment.

Morin[xxiii], 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 recursion process, where parts and effects turn to the whole, the whole feeds on the parts, and the essence of the whole is in each part. Computing, according to Morin[xxiv] means, from the Latin origin of *computare*: to analyze together, to compare, to confront, to understand.

Therefore, developing computational thinking is developing organizing/producing/complex thinking[xxv], in a cognitive dimension. Thinking, which is not only problem-solving but also problem-rising and problem-solving questioning, as a way of being and acting in the world, according to Kastrup[xxvi].

Understanding computational thinking developing in this new sensorial architecture of cognitive and relational ecologies, enhanced by digitality and connectivity, are present-time problematizations that challenge us to think and build a new cognitive policy in education.

This article aims to discuss the understanding of computational thinking development from the perspective of inventive learning , expanding the concept of cognition, to sustain that knowing is not just representing, but also producing reality.

Inventive learning helps us think about the present world in the process of accelerated transformation since it expands the concept of cognition involving the introduction of new issues, such as the creation, problem invention, and modulations of cognition in the contemporary world[xxvii].

It includes the experience of problematization that is revealed, through what Maturana and Varela[xxviii] called *breakdowns*, which are the cracks in the habitual cognitive flow forcing us to think. For Maturana and Varela, the world disturbs and this "disturbance" or breakdown corresponds, according to Kastrup[xxix], to the moment of problem invention, which is the crack, a bifurcation that shakes the usual recognition flow.

Hence, the concept of breakdown is fundamental to understanding that subject and world are co-engendered[2] by action, in a process of permanent transformation and subject to reinvention, since learning takes the form of a circle, in which the movement is that of return, renew, reinvent, re-start[xxx].

So, how can the co-engendering between the various entities that make up the city produce computational thinking from the perspective of invention? To understand this problematization, it is necessary to think about methodologies and pedagogical practices that can lead to the emergence of an OnLIFE Education path.

THE EMERGENCY OF AN ONLIFE EDUCATION

The world's algorithmization process problematizes the way of knowing and producing knowledge, in a context of digitality and connectivity, from which hybrid realities emerge.

The concept of OnLIFE Education has been constituting the triad research-development training in the International Research Group on Digital Education, UNISINOS/CNPq (GPe-dU). It is based on the concept of Hybrid and Multimodal

Education[xxxi], which subsidized the design and development of inventive methodologies and sympoietic, inventive, and gamified pedagogical practices[xxxii], validated at different levels and educational contexts. This movement led to the concepts of the symbiote and learning while miscegenation, and invention, by Michel Serres, expanding inventive cognition[xxxiii]. Also, it has been deepening the understanding of reticular and connective epistemologies, transorganic connective act, transubstantiation and atopic inhabiting[xxxiv]; onlife society[xxxv]; hyper complexity and sympoiesis[xxxvi] and Hyperobjects[xxxvii]. 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 connected, is characterized as an education connected to LIFE, which emerges and develops from present-time/world problematizations, in a hyperconnected reality. It is a concept in motion, in a network of concepts, methodologies, practices, and relationships that emerge from reticular and connective epistemologies[xxxviii]. Also, it comes from the understanding of digital technologies as technologies of intelligence[xxxix], which expand, externalize and modify human cognitive functions and, as environmental forces[xl], which problematize who we are, how we relate to one another, 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 appropriated in creation/co-creation processes. The OnLIFE Education paradigm, thus, implies an epistemological turn, a new cognitive policy in education, where the 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.

Thus, this article proposes to discuss the data produced in the pedagogical practice ‘Building a Gamebook’, which articulates the development of computational thinking (linked to the cybrid territory of the city[xli]. It orchestrates, from a theoretical-epistemological perspective, the urban and post-urban spaces hybridization[xlii],inventive cognition, gamified learning projects [xliii]and OnLIFE

Education[xliv]. This practice comes from a doctoral dissertation[xlv] within the scope of the research “THE CITY AS A LEARNING SPACE: Innovative pedagogical practices to promote citizenship and sustainable social development”, financed by Fundação Carlos Chagas and Itaú Social, developed by the International Research Group on Digital Education - GPe-dU UNISINOS/CNPq.

After this contextualization, the movements that built this teaching practice, arising from the cartographic method of research intervention, will be presented next.

BUILDING A GAMEBOOK: AN ONLIFE EDUCATION EXPERIENCE IN THE CIBRICITY – METHODOLOGY

The pedagogical practice entitled 'Building a Gamebook' comes from qualitative research, whose methodology is developed from the cartographic research-intervention method by Passos, Kastrup, and Escóssia[xlvi].

According to Passos, Kastrup, and Escóssia, cartography proposes a methodological review. The traditional meaning of the word methodology is imprinted in the very etymology of the word: *metá-hódos*. Research is defined as a path (hodos) predetermined by the given starting goals. For the authors, cartography, when proposing this reversal, transforms the *metá-hodos* into *hódos-méta*, bets on the experimentation of thought, a method not to be applied, but to be experienced and assumed as an attitude.

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. Instead of collecting data, the work is focused on data production, analysis, and intervention, as the research process brings out realities that were not given waiting for an observation. As research instruments, photo records, audio, video recordings and 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 cartographer-researcher as a reference for walking along the research path itself. The functioning of attention is an important clue in the formation of the researcher-cartographer, defined as open and concentrated, having four movements: tracking, touching, landing, and attentive recognition. This clue is related to the functioning of attention during fieldwork, understanding the field that ranges from the researcher's first concerns to the immersion in the investigation territory. In this article, the cartographic attention guided the fieldwork for the production of data, as well as the methodology for the pedagogical practice design.

The inhabited territory was K-12 Education, more specifically, two Elementary School groups. It covered 39 students, aged from 8 to 9 years old, from a Bilingual Education School (Portuguese-English). It took place in the city of Novo Hamburgo, Rio Grande do Sul, Brazil, between 2019 and 2020 (before and during the Covid-19 pandemic).

In the curriculum, there is the curricular component of Programming, developed at the *code.org* platform. The studies in Human Sciences in this school grade aimed at the city, (Brasil, 2017), referring to memory spaces, social and cultural diversities, the development of geographic, historical, and spatial analysis of perceived, conceived, and lived spaces, mapping languages, different textual genres, and digital technologies. The school is located in the Historic Center and was the first school founded in the city by German immigrants who arrived in 1824, therefore, it has part of its heritage and buildings in a protected area.

From the cartographic attention functioning: tracking, touch, landing, and attentive recognition[xlvii], the systematization of this pedagogical practice is presented in the image below.

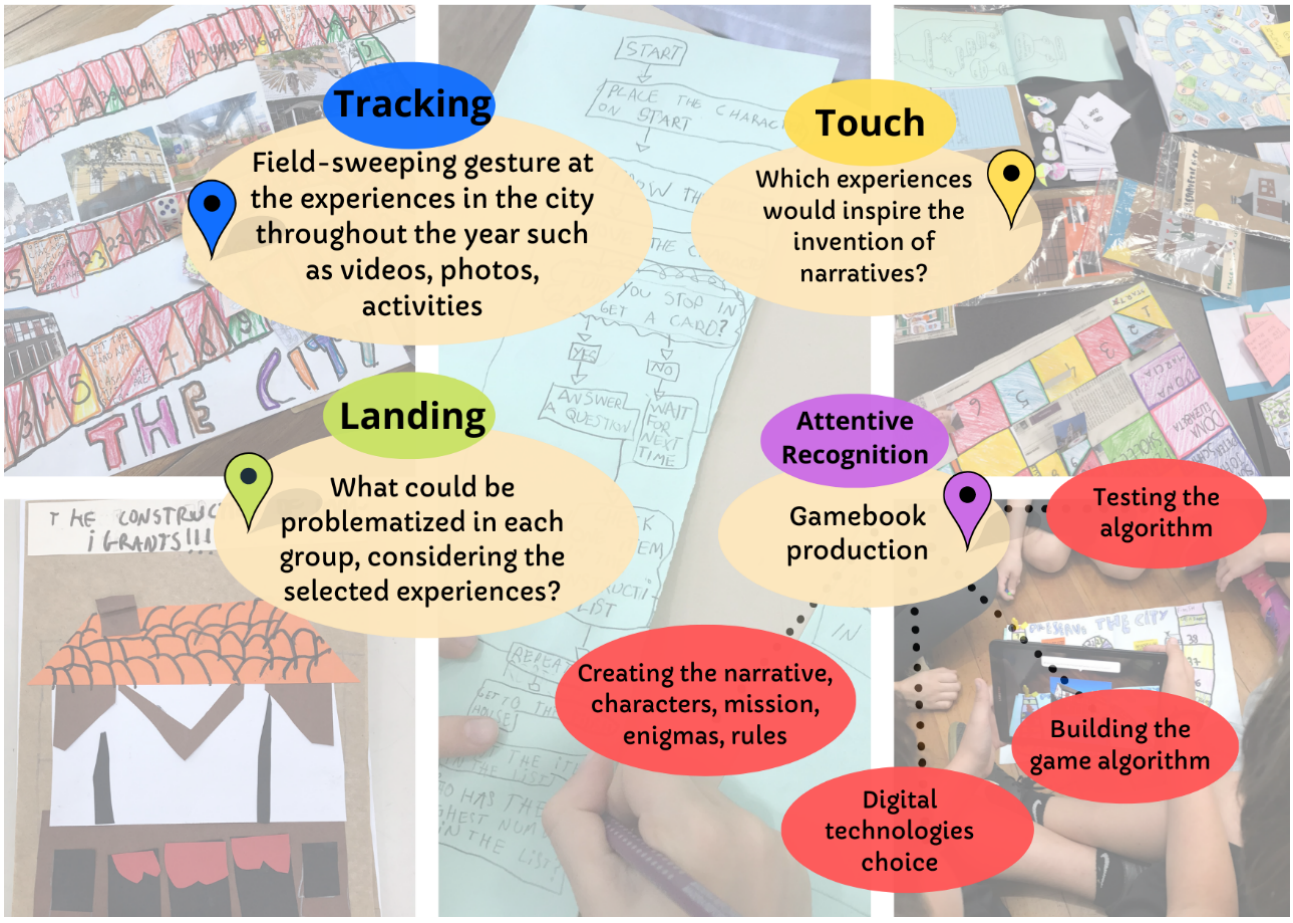

Image 1. Building a Gamebook - Conception

Tracking is a field-sweeping gesture aimed at a sort of moving target. It does not identify with a search for information. Considering all the experiences during the year 2019/2020, in the cybrid territory of the city, we organized the recording materials (photos, videos, artistic works, gamified trails) and explored them again.

Touch is the second variety of attention and manifests as a tiny glimpse that triggers the selection process. Something stands out, gains prominence, and demands attention. In this practice, which experiences would generate inspiration for the construction of the Gamebooks narrative? From there, the Landing movement would begin to take shape.

Once something generates the selection and changes the direction of attention, the landing movement begins. The landing indicates that the perception makes a stop and the field closes, in a kind of zoom, as if the researcher were looking at the field through a window. Here, each group established its connections with the experience lived in the city, seeking to establish the focus of the narrative that would permeate their Gamebook.

So the Attentive Recognition movement began to emerge, leading them to dive into their themes and produce Gamebooks that involved the construction of the narrative, choice of digital technologies, elaboration of the game algorithm, testing, and sharing games with colleagues.

The process of building the Gamebooks was followed up based on the cartographic attention movements, which guided the researcher, and the data produced, arising from this teaching practice, linked to the development of computational thinking in cibricity, will be presented below.

DISCUSSION AND RESULTS

The objective of the pedagogical practice entitled 'Building a Gamebook', consisted of telling the story lived throughout 2019 seeking clues on how computational thinking could be leveraged from experiences in the city, from the perspective of inventive learning and OnLIFE Education.

The results will be discussed concerning: a) the development of computational thinking in the city; b) the production of an inventive path, and c) the perspective of OnLIFE Education.

a) Regarding the development of computational thinking through experiences in/with the city:

From the analysis of the audio transcriptions and records in the field diary, there

was the construction of an initial understanding of what an algorithm is. This emerged from the mechanics and dynamics of the Gamebooks. Each game required thinking through simple and compound conditional structures, loops of repetition, and recursion. The image below shows the example of a Gamebook built by one of the groups, entitled The *Construction of the Immigrants*. In the image, it is possible to visualize the construction of the game rules through a flowchart algorithm, as well as part of the narrative, pieces, board, and cover. In this game, the narrative was about German immigrants arriving in Brazil and needing to build their houses. The mission was to collect wood along the way. For this, players had to solve puzzles about the history of German immigration and collect pieces that represented wood. In the end, the players would put together all the pieces and build the house in half-timbered architecture, which was brought by German immigrants and is still present in the Historic Center.

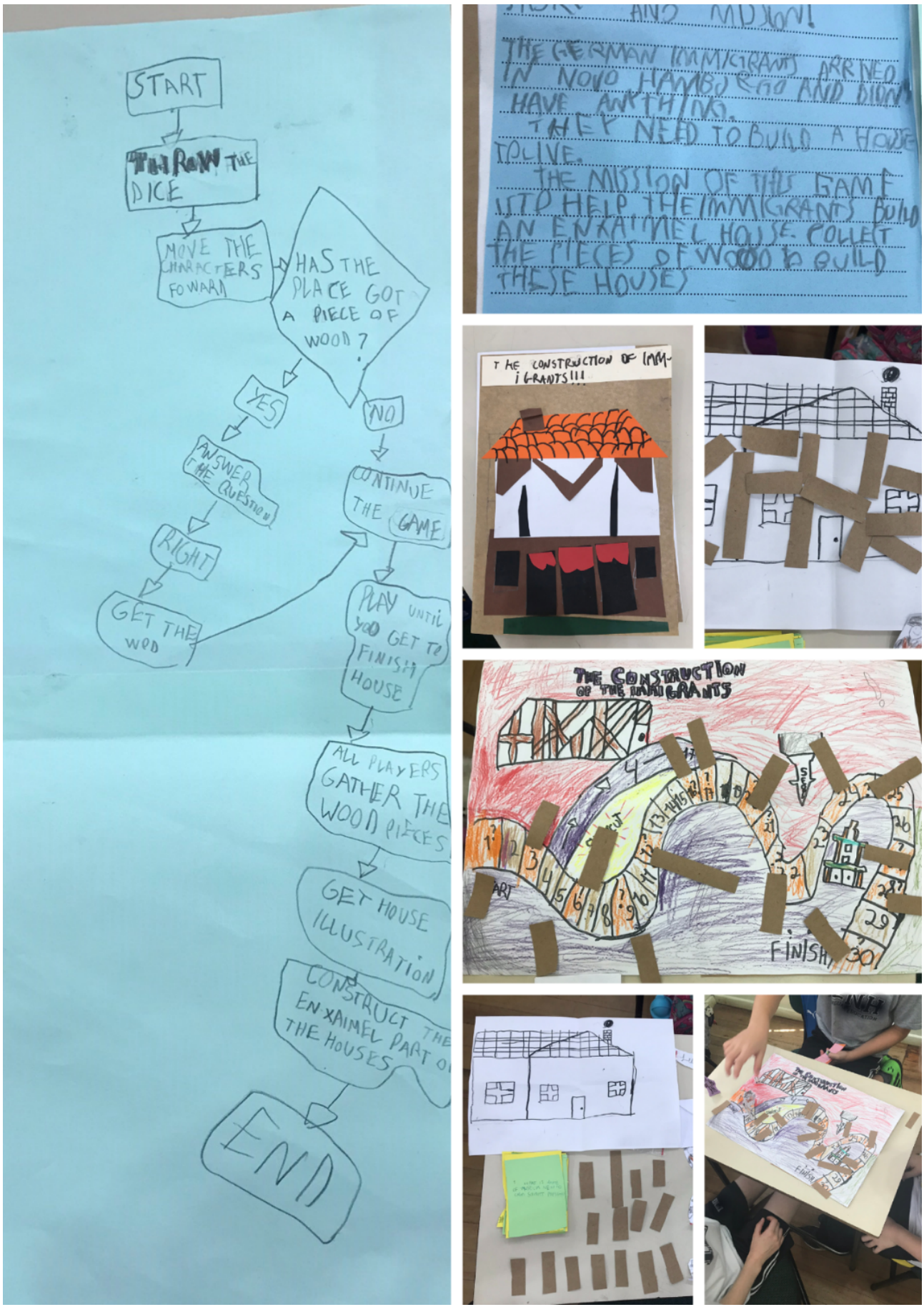

Image 2. The Construction of the Immigrants – Gamebook

Having to translate the rules of the game through a flowchart, the process brought a problem: *“Has this place got a piece of wood?”* This forced participants to make decisions halfway through, causing breakdowns[xlviii] in their computing activity [xlix]. Students realized that there were two possibilities, “Yes” or “No”, and they needed to decide what would happen in each of them.

It was necessary to think about the procedures[l] that would translate and build this set of rules, making it possible to understand the mechanics and dynamics of the game[li]. Such rules would allow the choice of certain actions that would be performed when certain conditions were satisfied or not. In the image below, it is possible to see this structure in the algorithm (pink and gray arrows), motivated by the central question of the game (yellow arrow).

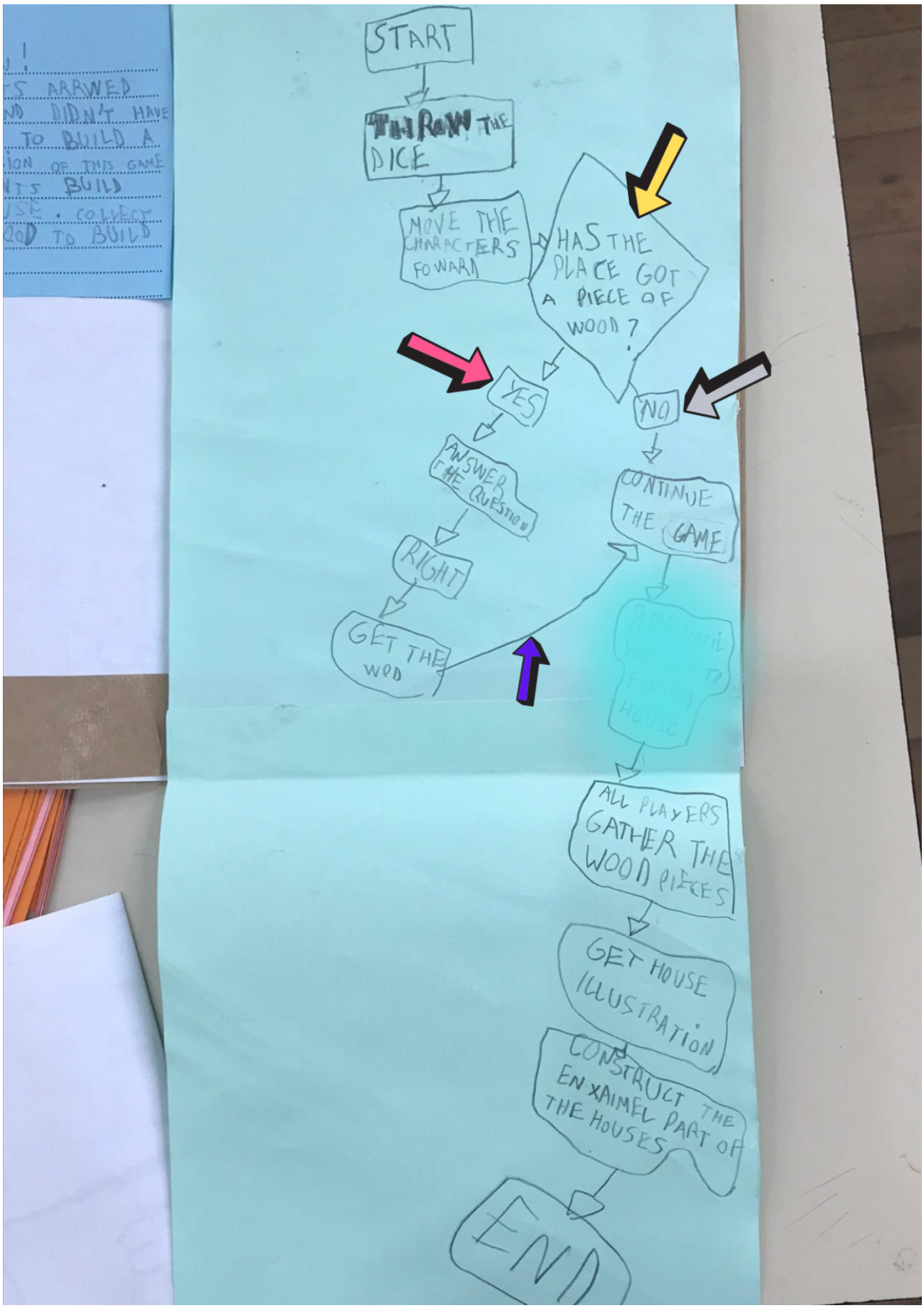

Image 3. Conditional Structures

There was also a movement of decomposition, because the fact of being organized in parts, in procedures, made it possible to focus on the statements, verify the presence of bugs, abstract them from the others and do the debugging.

Recursion emerged as a common feature in games when there are situations that make the player need to return to a certain point and restart the course. When creating the flowchart of the game's algorithm, they understood that they needed to call a procedure to repeat itself in the form of a circuit. It was necessary to analyze what would be the point of return and invoke the procedure itself, where the part turns to the whole, which was illustrated with arrows that directed to “Repeat”, “Throw the dice”, and “Continue the game” (blue arrow).

At the same time, the Gamebook's algorithm could lead to its infinite repetition. Behold, when faced with this situation, they understood that the structure of “play until” was required, thus emerging loops of repetition. The algorithm needs recursion so that the game can keep moving, however, the mission expressed in the narrative had an end, so a termination condition was needed to reach the end. In this regard, the group needed to analyze their algorithm again and determine when it should finish. The image below illustrates recursion and repetition loops in the algorithm.

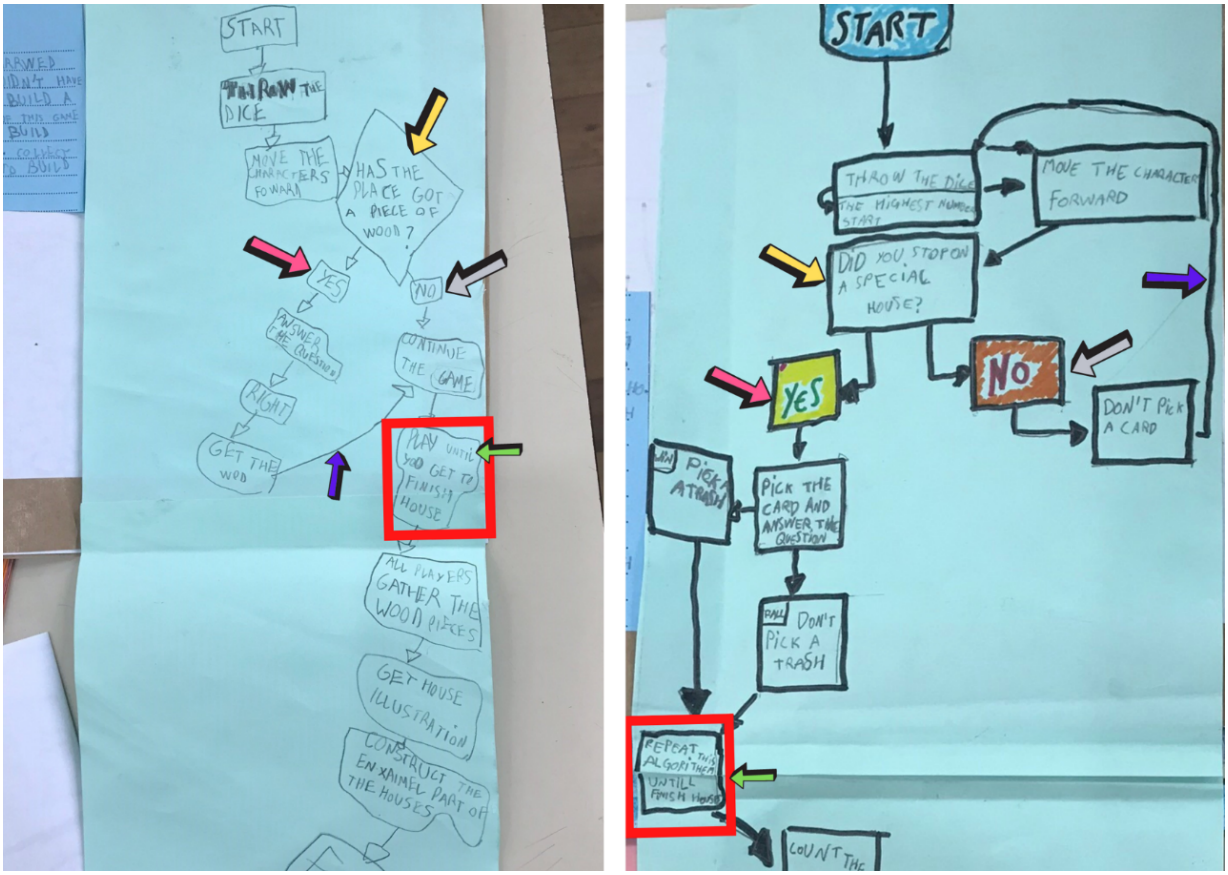

Image 4. Recursion and Loops

In the examples presented above (conditional structures, recursion, repetition loops), it was possible to understand the dialogic in the computing activity with its conjunction, disjunction, affirmation, negation, and condition operations. After building the algorithm, each group tested its own game, which involved playing it from reading the narrative and mission, verifying the procedures, debugging, and, afterward, switching the games among themselves.

[lii]

De Paula, Valente, and Burn (2014) ___understand that the creation of games is a way to enhance computational thinking because games are systems and thus, connect computing concepts with everyday life. It is an input, as the authors put it, for understanding the algorithm (a precise and ambiguous sequence of instructions) and consequently for programming, especially because the “if” command plays an important role in this practice. In other words, the development of a game is essentially a complex activity, and, in this practice, the city-related game was a potentiator of computational thinking.

b) Regarding the production of an inventive path in cibricity:

The construction of the Gamebook based on experiences in the city, led to experiences of problematization, causing bugs and breakdowns (Kastrup, 2010, 2015) [liii] in thinking, without there being a predetermined solution. The cultivation of experiences in the city (both physical and digital) made it possible to accept the problematizations and produced the gesture of attention. Inventive learning took place along the way, produced in the co-engineering between human and non-human entities in the context of cibricity in a cultivated way, to provide open attention to variation and unpredictability. 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 processuality, leading to an embodied experience and generating a relationship of belonging and involvement with the historical and cultural heritage. There was also an ecological view of what and who inhabits this space, and another relationship with time and with attention to learning.

The invention, as a policy, is a practice, not an imposition. It was constituted as an attitude, emerging from the collective and potentiated computational thinking beyond problem-solving. The experiences in cibricity developed computing activity, opening the way for the understanding of how to produce algorithms based on procedural thinking and debugging[liv]. Through these movements, the experiences of gamified learning projects produced assemblages (Kastrup, 2015) [lv] between computational thinking, cibricity, and students. These assemblages, in the sense of direct communication between them, between flows, made it possible for students, sensitive to the signs of the city, to develop their thinking process, which led to the construction of their algorithms.

The co-engendering between human and non-human entities in the city did not establish hierarchies or subordination. We sought to overcome dichotomies such as subject-object, individual-environment, teacher-student, and pedagogical practices that were tensioned to open up to the unpredictable.

c) Regarding OnLIFE Education:

It was possible to understand the computing activity occurring in flow, favoring the construction of the algorithm's understanding from the hybridization of the physical, biological, and digital worlds. The movement, in different spaces, physical, geographic, and/or digital, led to different experiences with the sense of inhabiting.

The experiences in cibricity brought problematizations connected with life, tensioning of methodologies and pedagogical practices, hybridization of times, spaces, technologies, presences, languages, culture, the search for overcoming dichotomies (subject-object, individual-environment) and centralities (either in the teacher, the content or the student), development of interdisciplinarity and transversality of

computational thinking and the perspective of problem invention. The gamified learning projects[lvi] proposed narratives with characters, missions, and puzzles, bringing an important aspect to think 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 projectslived, the paths were transformed into algorithms, and different ways of knowing and interpreting the city, both as a city of atoms and a city of bits, developed.

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 their daily lives, which guide or modify their living. Through excerpts extracted from the interviews, such as “an algorithm can help me in the sequence of my day”, “the bugs were not bad, they helped us 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 the understanding of the algorithmic language was built by living the experience.

CONCLUSION

The experiences that emerged from the practice, ‘Building a Gamebook’ led to the understanding that computing is living, knowing, and producing realities. They also led to the comprehension that the city's territory is re-dimensioned, it communicates, it is hybridized, where the human is a member of an ecosystem that connects many algorithms. That imposes a profound transformation in our dwelling conditions and our citizenship conceptions. The understanding of computational thinking potentiated in and with the city resulted from the adoption of a cognitive policy attentive to the process.

It raised curiosity about the preservation of historical and cultural heritage, architecture, biodiversity, physical and digital space, and technologies. This process, in connection, led to a more ecological understanding in which computational thinking is not reduced to programming, human, or technologies, nor the city to a space of geographical limits, but as a complex and communicative entity.

The process of creating and executing an algorithm, through the games invented about the city provided a connection beyond technique and utilitarianism. Computational thinking was embedded in life. Therefore, it was possible to understand computational thinking and the city emerging, producing, and being produced, from the perspective of inventive learning, in an OnLIFE Education experience.

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