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ARTICLE



THE METHOD OF CARTOGRAPHY AND SCIENCE EDUCATION: INTERLOCUTIONS

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ABSTRACT:

From a correlation of the scientific negationism scenario evidenced in the COVID-19 pandemic with the Eurocentric trajectory of Western science, as well as the establishment of truths, parameters and assumptions conducted and legitimized by it, some aspects to be displaced in the model current cognitive are reflected, in the sense of its vivification and its connection with life and with other knowledge. In this direction, betting on other perspectives and methods, the work aims to weave approximations between science education and the method of cartography, through a bibliographical review, in the following databases: Redalyc, SciELO and DOAJ, having been found only six works that met the inclusion criteria. Thus, the possible contributions of this methodology to science research and education are investigated and discussed, especially with regard to cognition policies, questioning the understanding of knowledge as a representation of a reality or truth. We understand that an inventive and emancipatory perspective of science, which embodies knowledge in access to experience, expands in singularities and multiplicities, building common – not univocal – territories, cultivating confidence and belonging.

Keywords:

Cartography method;
Western science;
Inventive cognition.

O MÉTODO DA CARTOGRAFIA E A EDUCAÇÃO EM CIÊNCIAS: INTERLOCUÇÕES

RESUMO:

A partir da correlação do cenário de negacionismo científico evidenciado na pandemia da COVID-19 com a trajetória eurocêntrica da ciência ocidental, bem como do estabelecimento de verdades, parâmetros e premissas conduzidos e legitimados pela mesma, são refletidos alguns aspectos a serem deslocados no modelo cognitivo vigente, no sentido de sua vivificação e de sua ligação com a vida e com outros saberes. Nessa direção, apostando em perspectivas e métodos outros, o trabalho objetiva tecer aproximações entre a educação em ciências e o método da cartografia, por meio de uma revisão bibliográfica, nas seguintes bases de dados: Redalyc, SciELO e DOAJ, tendo sido encontrados somente seis trabalhos que atendessem aos critérios de inclusão. Assim, são investigadas e discutidas as contribuições possíveis dessa metodologia à pesquisa e educação em ciências, especialmente no que diz respeito às políticas de cognição, interpelando o entendimento corrente de conhecimento – considerado uma representação da realidade ou da verdade. Entendemos que uma per-

Palavras-chave:

Método da cartografia;
Ciência ocidental;
Cognição inventiva.

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spectiva inventiva e emancipadora de ciência, que encarna o conhecer no acesso à experiência, amplia-se nas singularidades e multiplicidades, construindo territórios comuns – não unívocos –, cultivando confiança e pertencimento.

EL MÉTODO DE LA CARTOGRAFÍA Y LA EDUCACIÓN CIENTÍFICA: INTERLOCUCIONES

RESUMEN:

A partir de una correlación entre el escenario de negacionismo científico evidenciado en la pandemia COVID-19 y la trayectoria eurocéntrica de la ciencia occidental, así como del establecimiento de verdades, parámetros y supuestos conducidos y legitimados por ella, se reflejan algunos aspectos a ser desplazados en el modelo cognitivo actual, en el sentido de su dinamización y su conexión con la vida y con otros saberes. En esta dirección, apostando por otras perspectivas y métodos, el trabajo pretende tejer aproximaciones entre la enseñanza de las ciencias y el método de la cartografía, a través de una revisión bibliográfica, en las siguientes bases de datos: Redalyc, SciELO y DOAJ, habiéndose encontrado solo seis trabajos que cumplieron con los criterios de inclusión. Así, se investigan y discuten los posibles aportes de esta metodología a la investigación científica y la educación, especialmente en lo que respecta a las políticas cognitivas, cuestionando la comprensión corriente de conocimiento – considerado una representación de una realidad o verdad. Entendemos que una perspectiva inventiva y emancipadora de la ciencia, que incorpora el conocimiento en el acceso a la experiencia, se expande en singularidades y multiplicidades, construyendo territorios comunes, no unívocos, cultivando la confianza y la pertenencia.

Palabras clave:

Método de la cartografía;
Ciencia occidental;
Cognición inventiva.

INTRODUCTION

And, more and more, we have the feeling that we have to learn again how to think and write, even if for this we have to separate ourselves from the security of knowledge, methods and languages that we have (and that own us).

Larrosa, 2017, p. 11.

Before a pandemic scenario and its political, educational, economic, social and scientific complexities, it is important to anchor writing to this situation, investing in ways of thinking and doing research that dialogue with the historicity that permeates human beings, as well as in the commitment that they have with the transformations of these realities (Freire, 2013). A phenomenon that gains body and strength in this scenario – or, at the very least, visibility – is the so-called denial, or disqualification of science and its important contributions to the contour (or mitigation) of the situation of the COVID-19 pandemic (Barcellos, 2020).

This disqualification or “denial of science”, according to Marcília Barcellos (2020), does not start (or end) with the pandemic, but is evident with it, being inserted in a previous context, more intensely related to a “crisis of truth” than with the disinformation phenomena themselves. The same author highlights the correlation of this discredited situation of science with the distancing of scientific research and theories, in its place of

authority of knowledge, from what reaches the general public, the result of a content education and the ways in which science dialogues (or fails to dialogue) with popular and everyday knowledge. In this sense, considering the overlaps and political conveniences, this crisis can be seen through a prism that announces a warning sign:

The scientific truths of banking education are just self-proclaimed truths because they are never questioned before the people. In this context, the Science discourse is just another discourse as dogmatic as many others existing in the daily life of the people. Science is just another white, masculine and European discourse like so many others, like so many other discourses that exclude, like so many others that oppress (Barcellos, 2020, p. 1502).

The paths trodden today in knowledge are basically heirs of Western science and philosophy: European, white, male, elitist routes. In fact, according to Ramón Grosfoguel (2016), a Puerto Rican sociologist, Western Universities structure their thinking and their science from men from 5 countries (France, Germany, England, USA and Italy), forming the contemporary epistemic foundations. According to the author, this is knowledge – with a Cartesian basis – which, by exalting the pure exercise of thought and reason, produces a split between mind (reason) and body. Now, if the body does not matter, it does not matter where this body is located and the complexity of cultural, social, economic, political factors that cross it and, in addition to a reason that can be *purified* from these crossings, a certain thought can be considered universal. In this way, it becomes applicable in any place and situation, and what is more problematic, within a statute of truth, since this is not assumed as a point of view. According to the author, this is a provincialism that disguises itself as universality, and Westernized universities continue to carry this Cartesian legacy in the validation processes of the production of science and knowledge: “Even those who are critical of Cartesian philosophy continue to use it as a criterion to differentiate what is science or not” (Grosfoguel, 2016, p. 30).

Still with Ramón Grosfoguel (2016), this supposedly universal knowledge structure is reproduced in non-European locations, even if their social, cultural or geographic realities are different and demand other ways of thinking, feeling and acting. This concentration is not naive, nor is it innocuous, but it is a privilege, since there are types of knowledge and forms of knowledge considered superior, while geopolitically non-Western cosmologies and worldviews are considered unscientific or inferior. What escapes from the premises established by universalized Western thought is discarded because of its form, methods, contents or cosmologies (Rosa, Alves-Brito and Pinheiro, 2020). Thus, knowledge that is intended to be incorporated, that assumes its own subjectivity, singularity, cosmogony, gender, race, class, place of speech – that is, in short, situated – still carry the stigma of biased, partial, invalids:

We are caught in a violent colonial order. In this sense, the academy is not a neutral space, nor is it simply a space of knowledge and wisdom, of science and erudition, it is also a space of v-i-o-l-e-n-c-e. (...) They allow the *white subject* to position our discourses back at the margins, as deviant knowledge, while their discourses remain in the center, as the norm. When they speak it is scientific, when we speak it is unscientific (Kilomba, 2019, pp. 51-52, emphasis added).

In line with the Portuguese theorist Grada Kilomba, this normative science that claims to be neutral and universal constitutes many forms of violence and alienation, disregarding deviant knowledge or invalidating it as a science. In this way, what implications derive from this excluding trajectory that has been traversed by knowledge and science? What relationships are established with society by a knowledge that homogenizes, institutes truths that, considering themselves to be objective and universal, are judged to be neutral, impartial, precise and unequivocal, acting as such?

What is at issue is not blaming science, but implying current ways of thinking and doing science with the backdrop of resurgence of denial, reflecting that theoretical and epistemological aspects can (or should) suffer affectations and displacements towards their enlivening and of its connection with life and with other knowledges. Here, it is understood that science as a representation of universal truths, based on pretensions

of neutrality, impersonality, objectivity, linearity, contributed and continues to contribute to the establishment of the described scenario. In this sense, thinking about other directions, ways, criteria and strategies also involves rethinking methods, and it is in this field that this work is inserted.

The aim of this article is to bring together science education and the method of cartography, through a literature review in which possible contributions of this methodology are investigated, as well as the theoretical-epistemological perspectives it carries, especially with regard to policies of cognition and the displacement of the understanding of knowledge as a representation of a reality or truth.

At first, the method of cartography, its main clues and traces will be briefly presented, in order to situate the reader in the territory of this research. Then, the bibliographic survey method will be described, which was guided by the question: how has the cartography method been used by scientific research in the field of science education and what have been its main contributions? This survey was carried out in the following databases: the Network of Scientific Journals from Latin America and the Caribbean, Spain and Portugal (Redalyc), the Scientific Electronic Library Online (SciELO) digital library and the Directory of Open Access Journals (DOAJ). Finally, the main results found will be commented, with the theoretical contributions of the works, which will be presented and discussed, observing their contributions to scientific research and science education.

THE CARTOGRAPHY METHOD – SOME CLUES

*Cartographic research understands knowledge as the production of reality
and research as a dip in the plane of experience in which the self and the world emerge,
the one who knows and the one or what is known.*

Passos & Kastrup, 2013, p. 396.

The “scientific truth” is, in its modern version, proven by its alleged “controlled practices”, in which the scientist would be a faithful witness of the observed fact. Science, from a cartographic perspective, (re) takes its inventive origin, insofar as knowing is creating realities, thus announcing political consequences. It points to shifts in the modern vision that distinguishes inventions from “true discoveries” – those that would be guaranteed through the researcher’s “neutral gaze” and “objectivity”, properly isolating the variables involved (Passos & Kastrup, 2013; Barros & Kastrup, 2015). Cartography therefore intends to “push the limits” of methodological procedures, reversing the primacy of goals and returning it to the path, to the research process (Passos, Kastrup & Escóssia, 2015).

The conception of research as a representation of an object dates back to the emergence of modern science. As Isabelle Stengers (1993) points out,¹ modern science emerges as a unique invention, configuring itself in a certain way and bearing as one of its main characteristics the separation between the scientific object and the scientist. What makes modern science unique is a scientific practice that is largely confused with the invention of the experimental device, and goes back to Galileo. Through this device the scientist seeks to separate the subject and object of knowledge. (...) Subject and object are not transcendental categories, but historical configurations. The experimental device appears as a possibility of putting hypotheses to the test, that is, the scientist’s inventions or fictions (Barros & Kastrup, 2015, pp. 53-54).

The understanding of knowledge as a representation of reality, related to a vision of science that *discovers*, that portrays the truth, as if there was a possible or correct way to do it, has been crossing our schools (institutional, family, biographical), not being simple to work in other ways. We almost consider it natural to look at the world as an object and us as subjects – the custom. In this sense, research that articulates education in science and cartography questions reproductive practices, based on a model to be followed: “Since it belongs to the order of representation, the decal needs to isolate what serves as a model and artificially organize, stabilize, neutralize the multiplicities according to the significances and subjectivations that are already yours.” (Cavalcanti, 2018, p. 26).

The criticism that is now made to the current cognitive model does not intend to discard it, but to broaden it, extend it, in an inclusive, creative and inventive perspective, incarnated, taking it as an *enactment* proposal: knowing is doing. Taking knowledge as creation requires, instead of describing experience, accessing it. Conceiving knowledge as a representation of the world or as a creation is not just a theoretical position, but a *cognitive policy*:

The concept of cognitive politics indicates that knowing involves a position in relation to the world and oneself, an attitude, an *ethos*. Therefore, the practice of a method is inseparable from the problem of cognitive policy, which configures a certain way of doing research, inhabiting a territory and placing oneself in the relationship of knowledge (Passos & Kastrup, 2013, p. 401).

The cartography method, presented in volume 1 of the book *Mil Platôs* by Deleuze and Guattari (1995), is commonly used in researches that take into account existential territories (Alvarez & Passos, 2015; Cintra *et al.*, 2017), in the sense that these territories or research fields are thick, in contrast to being taken as flat, shallow, static or linear; they assume complexities and different strata or spheres. The researchers accept the premise of transforming in order to know, or knowing by transforming, seeking research that is an intervention.

Cartography is a method formulated by Gilles Deleuze and Félix Guattari (1995)² which aims to follow a process, and not represent an object. (...) From the outset, the idea of developing the cartographic method for use in field research in the study of subjectivity moves away from the objective of defining a set of abstract rules to be applied. It does not seek to establish a linear path to an end (Passos, Kastrup & Escóssia, 2015, p. 32).

The cartographic practice of monitoring processes distances itself from the logic of data processing, which would refer to computational models, disconnected from social, historical and affective contexts. This pretension of describing states of things, of data and information collection that would be in the field, assumes facts and phenomena available and “observable”, longing for the critical eye of the researcher to configure themselves as “scientific discoveries”. This view is a result of a static conception of nature, of its objectification, with data collection for further analysis configured in a linear and unidirectional view. Understanding the process as processuality is considered the “heart of cartography” and, taking the researched processes as already ongoing, the research begins “in the middle, between pulsations” (Barros & Kastrup, 2015, p. 58).

General routes of the route are outlined, but the itinerary is not unalterable. In an image, it is as if, on a journey through an as-yet-unknown city, a route of wandering and visitation was conceived, but during the walk, when you bump into a street artist, it was possible to take a little longer, or cross streets to photograph a sculpture, in detours that, instead of betraying the primary purpose of getting to know the city, contribute to a broader and deeper understanding of that place. Furthermore, the course of the research repositions researchers in the field and, thus repositioned, acquire new perspectives and gazes on the same research.

The instant that emerges from the event supports the substantiation of the investigation, and the habitation of the territory requires a cultivation that situates the cartographer as an apprentice, who seeks to be found by the event, rather than finding what one intended to see (Alvarez & Passos, 2015). Therefore, we seek to suspend the observer’s point of view, escaping the pretensions of *representing* reality:

(...) the dissolution of the observer’s point of view denaturalizes the reality of the object and allows the researcher to open up to the different points of view that inhabit the same experience of reality, without letting himself be dominated by those who seem to be true at the expense of others that seem false. Thus, dissolution does not mean, under any circumstances, the abandonment of observation, but rather the adoption of a gaze where there is no separation between objective and subjective. It is about the contemplation of the subject/world co-emergence (Passos & Eirado, 2015, p. 110).

In cartographic research, the research field emerges with the researcher, establishing, with the slips between practice and theory, a problematic field (Alvarez & Passos, 2015). Avoiding the purification of an object or an experience, contagion is sought: to allow research to be contaminated by it. Even allowing oneself to be

constrained by the experience, giving research and writing the weight of life, the weight of form and, on the other hand, not intending to freeze its movements, its escapes, its trails. Being in the field as an existential territory is also to move the paths of research based on crossings, avoiding separating theory and practice, knowing and doing. Avoiding alienating the written from the lived, the event is recreated – as a *life-text* transposition – and the form is reinvented – insofar as it affects the problematic field, so that it is no longer what it used to be.

In cartography, the encounter of researchers with the field is understood as data production and collection, considering the emergencies that arise or, according to Laura Pozzana de Barros and Virgínia Kastrup (2015), what did not yet inhabit the “sphere of the already known”. In the research process, the aim is to open doors for the manifestation of “intensities seeking expression”, understanding that these data are not produced only by researchers, but in a joint and reciprocal production, which takes place in the meetings: “There is transformation from experience to knowledge and from knowledge to experience, in a circularity open to the passing time. There is *co-production*.” (Barros & Kastrup, 2015, p. 70, emphasis added).

In this way, the non-prescriptive character of cartography emerges: despite the rigor sought in the attitude and gaze of those who research, the methodological rigor is re-signified, guiding it towards life and its emergencies. The construction of the attitude of the researchers involved, therefore, is a sensitive point in cartographic research, trying to pursue an ethical and coherent commitment. Therefore, there is a rigor in the cultivation of attitudes and postures, aiming to achieve greater precision in concentrated but not focused attention. This attitude allows that, in the research situation, instead of focusing only on the goals - *capturing* what could eventually *function* as confirmation or refutation of hypotheses -, a stalking attitude is cultivated, not focused, although concentrated, attentive to the experience, to emergent moments, to what cannot be predicted, locating clues and signs. There is less emphasis on the number of stages of development and greater investment in the work of cultivating and refining the researcher’s gaze.

METHODOLOGY

Here we present some clues found in a literature review motivated by the following question: how has the cartography method been used by scientific research in the field of science education and what have been its main contributions? As mentioned above, the databases used were: Redalyc, a Latin American database that indexes scientific journals with open access and non-profit making; SciELO, also Latin American with open access and cooperative model; and DOAJ, of Swedish origin, which hosts open access journals curated by the community. The survey was carried out from October to November 2020, with different strategies and keywords, as will be described below – according to the possibilities and resources of each database in question. The inclusion criterion for the articles was that they dealt with science education – or that they articulated education and science in some way – and, in addition, that they worked with the method of cartography.

In the Redalyc database, we initially resorted to the descriptors: “cartography method” and “science education”. As this database did not produce a restrictive link between the words that are placed in quotation marks, this search had to be reconfigured by a single keyword: cartography. In order to make a cut, as more than 4000 works were found, the Education for refinement area was selected. Of the 546 articles found thereafter, there was a second sieve carried out using the command “CTRL+F”, locating those with the word “science”. In this way, it was possible to establish an articulation of education, science and cartography, with 56 articles being found. However, as among these there were many works in the field of physical geography (cartography as the study of maps), as well as other uses of the term, a selection was made through the title, abstract and floating reading (when necessary) of the texts, and only 4 were found that used cartography as a research method.

In the SciELO database, where it was possible to use *Boolean operators* – in this case the *and* quotation marks –, it was possible to perform the search: “cartography” *and* “science”. 35 works were found and, after reading the titles and/or a floating reading of the works, only 1 met the inclusion criteria. In the DOAJ

database, the search was in English, with the words “*cartography method*” (thus, in quotation marks). 16 works were found, only 1 meeting the aforementioned criteria. The different ways of searching and inserting descriptors are directly related to the specifics of each database.

Of the 597 works found, only 6 met the inclusion criteria, which were read and analyzed in their entirety. The articles found, their authors, the year and journal in which they were published, as well as the research location (base) in which they were found, are listed in the table below:

Table 1. Articles found in the Bibliographic Survey on the interlocution between the cartography method and Science Education.

| Work title | Author(s) | Year | Magazine | Base |
|---|--|------|-------------------------------------|---------|
| Cognition in question: invention, learning and Mathematics Education | Giovani Cammarota; Sônia Maria Claretto | 2012 | Educational Praxis | DOAJ |
| Possible encounters: experiences with theatrical games in science education | Thiago Rannieri Moreira de Oliveira | 2012 | Science & Education | Redalyc |
| Eco-logic: Efigênia between art and life | Kátia Maria Kasper | 2014 | Science & Education | Redalyc |
| Knowledge networks: interdisciplinary thinking | Marcus Alexandre de Padua Cavalcanti | 2018 | Periphery | Redalyc |
| The University-School Relationship in Teacher Education: Reflections of a Research-Intervention | Luciana Lobo Miranda; Priscila Sanches Nery Oliveira; José Alves de Souza Filho; Suzana Kérzia Rocha Bezerra Sousa | 2018 | Psychology: Science and Profession | SciELO |
| The threads that weave together science learning and teaching | Maria Neide Carneiro Ramos; Maria dos Remédios de Brito | 2018 | Essay Research in Science Education | Redalyc |

Source: The authors.

It is worth mentioning that the methodology used in this search, despite having covered different forms of research, covering different databases, certainly does not exhaust this dialogue. As the present work does not consist of State of the Art type research and seeks to collect and point out qualitative aspects of this dialogue, we bet on the reasonableness of the scope and bases chosen. However, to expand this research, continuing the findings and reflections, it is possible to include databases of theses and dissertations, as well as a direct search in Scientific Journals that host science education. A similar review was performed by Cintra *et al.* (2017), entitled *Cartography in scientific research: an integrative review*. The authors analyzed the use of cartography as a method in scientific research, working with Lilacs, PubMed, Web of Science and SciELO databases. We verified, through a fluctuating reading of the 37 works reviewed in the research, that 25 (67.5%) were located in the health area and the others in the field of arts, social work, among others and, as none of them dealt with precisely science education, were not included in this review.

The main theoretical contributions of the six works found will be addressed, analyzing the context, the methods of data production, the cultivation of the researcher's posture, in the sense of betting on proceduralism and access to experience, but mainly the discussions on cognition policies (Passos, Kastrup & Escossia, 2015), noting the main criticisms of the current scientific representational model. This choice was made in order to reflect the contributions of the cartography method to science education in the direction of broadening the view of cognition as representation, by opening up to inventive cognition – as will be seen below.

MAIN THEORETICAL RESULTS: SINGULARITIES AND COMMONS

The present bibliographical survey revealed, mainly, that the cartography method in science education has been used as an instrument to question the representational cognitive model, a discussion present in all the works found (Cammarota & Clareto, 2012; Oliveira, 2012; Kasper, 2014; Cavalcanti, 2018; Miranda *et al.*, 2018; Ramos & Brito, 2018). The types of learning hegemonically contemplated or constituted were also problematized, as in the works of Ramos and Brito (2018), Kasper (2014) and Cammarota and Clareto (2012).

Cammarota and Clareto (2012) present an interlocution between Mathematics Education and the notion of invention, in field research in a public school in Juiz de Fora (MG). This dialogue does not take place from the perspective of a subject who invents, in a sense already accepted or considered *good* in itself, but seeking to distance himself from the seduction of establishing what is good or bad - he does not take invention as *good* at all, nor *the representation as evil*, in a moralizing dimension. The authors carry the invention of meaning when they propose that it produce displacements and reconfigurations of oneself and the other in this classroom space, in experience, as well as – and through – the problematization of constituted cognitive forms. As an example, they question the classic division model:

All parts into which an integer is divided are necessarily equal. However, by saying that he gives more cake to those who like it more, one of the students problematizes one of the assumptions that found the division operation through an affective force. The idea of sharing that underlies the division is called into question. Mathematics is problematized and, by embodying a world, it constitutes itself (Cammarota & Clareto, p. 600).

The invention does not happen, therefore, from the void, it is created from and in experience, producing differentiations, giving place to the unexpected, considering that knowledge is reinvented there, in the encounter, not intending to dogmatically exclude the canonical models, but asking them questions, questioning their universality, realizing the political implications they carry, making room for recreation, in a different attitude, to the processes of knowing and researching. In this way, invention, from a cartographic perspective, does not seek to take itself as a model, it asks how to question a type of truth without proposing another to take its place; it reflects on how to make trustworthy a knowledge that does not want to take it for granted. It is possible, then, to take knowledge as a search for meanings, implications and values, in an ethical journey instead of moralizing captures between *good* and *evil*.

The question of knowledge, then, shifts from “*which discourse is truer?*” to “*what does this discourse imply? What kind of existence is this discourse at the service of?*”. Linked to ethics, a political dimension also appears: what kind of relationship is established with knowledge? What kind of relationship is established with learning? These questions highlight knowing rather than knowledge. That is, knowing referring to an attitude, thus carrying a political dimension: cognitive policy (Cammarota & Clareto, 2012, p. 588, our emphasis).

This transference of “*which speech is truer?*” to “*what does this discourse imply? What kind of existence is this discourse at the service of?*”, in the highlighted excerpt above, it is pertinent when we think about the ways in which we have established debates, whether political, scientific or religious: our tendency is to disqualify an idea by treating it as “*bad*” or “*false*” in itself – when we do not demean or scorn, in the act, whoever defends the depreciated idea. It is a challenging exercise, which does not aim to nullify our indignation and the confrontation that we can make of the ideas we understand as “*dangerous*”, but experiencing this exchange can, in addition to enabling dialogue, broaden the critical perspective, placing less focus on valuation than in the historical articulations of those ideas, as well as in their social, cultural, economic, political, subjective implications.

The method of cartography was found, in two of the works in question, associated with the power of art as a way of giving new meaning to the politics of knowledge and science (Oliveira, 2012; Kasper, 2014). Oliveira (2012) brings the cartographic approach of theatrical games in science education with 8th and 9th grade students from an Application College in the state of Sergipe and, in this way, problematizes the lack of

epistemological interest in the body in science teaching out of their rational capacity, as well as pointing out potentialities of creation and inventive knowledge from the access to experiences with these students. There is the suspension of the notion of script which, from a cartographic perspective, is not a prescription to be fulfilled, but a proposal to be recreated, becoming a means and not an end in itself. In this sense, the author incarnates, in his research, the procedurality proposed in the method of cartography, taking, from the game, what emerges, the unusual, which was not fixed in a field, but which emerges through and in the experience:

The marginal aspects of games must be valued in the game, such as chance, the unexpected, the improvisation, the discontinuous, because the theatrical game summons what we have learned to call “scientific knowledge” and its learning experience to respond to the needs of the body, incarnating in life, leaving oneself open to chance, opening up to freedom and the dynamics of forces so as not to let things settle, to get them out of their stupor (Oliveira, 2012, p. 564).

For the author, although science and knowledge precede the mechanistic paradigm, they were captured by it, constituting practices that aim to classify, dominate, control and, in this sense, science is inserted as one among other metanarratives that aim to frame and fix things. Discussing the fictional character of thought in his work, he situates fiction not as an opposition to reality, but as the possibility of creating truths. It presents the possibility of learning outside reproduction, recognition and representation, opening and remaking bodies and life, disarranging what was already constituted and established. In a refusal to what is *one*, tied to identity and representation, singularities, deviations, multiplicities are underlined, making room for *incarnated* knowledge: “Bodies that, when they play, not only learn certain scientific knowledge, but learn that from that it is possible to establish a new world, it is possible to do something with it, from it.” (Oliveira, 2012, p. 564). Within this proposal of creative and inventive cognition, the author also suggests the reconfiguration of the subject he knows.

The classic epistemological subject of scientific education, which could assert a coherent identity in itself, now wavers, breaks down, is nothing more than an invention. And, if it is an invention, it is always possible to invent other ways of being and existing in science education, ways of becoming, of entering into becoming (Oliveira, 2012, p. 567).

In turn, Kasper (2014) discusses the teaching and learning of science in non-formal spaces, by intertwining with the biography of a scrap metal artist in public spaces. Through analyzes and affectations arising from observations and interactions with this artist, as well as her inventive and creative artistic work, the author relates this action to a re-signification of the teaching and learning process in its possibilities. Learning with what is open to the unexpected, the break in linearity, the singularities that emerge in the meeting: “Efigênia presented herself even without people buying her dolls and cloaks; all they had to do was get closer. Perhaps what matters most is this device created among the passers-by at the fair: enhancing contact situations” (Kasper, 2014, p. 340). The author also demands an expansion of the concept of science and training, of “deautomatization” and of not imprisonment in identities, emphasizing what remains “untamable”. Confronting the forms of *capitalistic* subjectivity and social control with permanent resistances and differentiations, it offers science education other ways of being, perceiving, feeling and acting, that avoid modeling attempts, conceiving training beyond prescriptions and norms, placing in suspension the established ways of teaching and learning, in their methods and places:

With Efigênia, we learn possibilities for thinking about the environment and education in connection with the arts. The power of Efigênia’s narratives involve (*sic*) equally adults and children who listen to them. Efigênia develops a didactics of invention, which escapes from models and molds. It escapes the models both with regard to the “how” and “where” to teach, and with regard to the ways of life stated in such narratives. It teaches us to cross the world and create other worlds. Affirmation of other modes of existence (Kasper, 2014, p. 333).

Cavalcanti (2018), on the other hand, criticizes the fragmentation of knowledge in an arboreal model, evoking the metaphor of the tree to deal with the hegemonic epistemological model, in which established cer-

tainties and truths would be the roots of this tree, from which all knowledge originates; the firm trunk would be constituted by irrefutable premises, with branches opening up in different areas of knowledge – the main fertilizer being *the thirst of knowledge and curiosity*. In this model, the branches and leaves only keep among themselves their common origin and, in this way, knowledge is hierarchical, information flows are regulated, centralized. Memories, history, culture, knowledge production are organized and determined by a center (trunk), in a linear movement. In a critique of the global and Western model of scientific rationality, the author places, in this sense, as an alternative to the tree, the Deleuzian idea of rhizome,³ in which the ramifications do not start from a center, and it is not possible to identify the entry point: the entrances and outputs are multiple, and the connections between the different points are made by contact or “contagion”. According to the author, fulfills

Opening the field of vision of areas of knowledge, denying dogmatic certainties and theoretical isolations in favor of opening up to the plurality of relationships and perspectives through a more critical and reflective look at the world and the very idea of knowledge (Cavalcanti, 2018, p. 28).

Miranda *et al.* (2018) analyze the university-school relationship in a space for training basic education teachers, in an intervention-research carried out through an extension course in a public school in Fortaleza (CE). Thinking of teacher education as an inventive act, of *deforming* more than forming or formatting, they destabilize the place of “privileged credibility” of the university, questioning what is usually *elaborated* in the university space to be *applied* in the school. The university, a notable representative of scientific knowledge and the establishment of truths, generally occupies the position of who “takes” knowledge. Through a cartographic posture, the authors seek to detach themselves from their affixed role as specialists or “science inspectors”, putting into debate the place of power that researchers usually occupy, and putting themselves in a position of exchange. They point to the creation of other discourses about the school, not only as a place of reproduction, bankruptcy or lack, but also of the power that inhabits there, denaturalizing the meanings of get to know, knowing and researching.

As participating teachers analyzed the challenges involved in their teaching practices, they experienced the vicissitudes involved in the micropolitics of everyday school life. The order of everyday life loses its naturalness when the actors begin to problematize the power games present in each challenge. On the other hand, teachers also start to recognize themselves as creators of their teaching practices and institutional daily life (Miranda *et al.*, 2018, p. 312).

Note that the power games in question tend to escape the gaze focused on the research goals and objectives. The processes that break out, the micropolitical elements, so often nebulous and inexact – escaping the categories and classifications – are dissonant with unisonous representations of a field without edges. In the same way, the fact of denaturalizing the “daily order” implies precisely suspending the attempts to portray orders, scenarios or contexts, to stabilize them in formats consistent with confirmations or refutations of hypotheses and models.

Finally, Ramos and Brito (2018) think about learning in science education, reflecting on how royal science (as they report to modern science) can intersect with a nomadic science during science classes. The authors associate Piagetian constructivism with the means of legitimizing a way of knowing based on the division between subject and object: a subject who acts *on* the environment and *on* the other, receiving stimuli in return and thus formulating, building and reconstructing his thought. According to the authors, the school was *seduced* by scientific thinking, in the sense that educators are often *applying* what they already know, neglecting creation and invention, a model referred to in the work as *recognition*. In this way, the current cognitive representational model is centered on norms, codes, principles and representations, concentrating the power to prove, adapt, impose and remain silent: the student enters a process of *enculturation*,⁴ in which he transitions from not knowing to knowing the science, in a linear, mechanized and cumulative way. For the authors, a nomadic science escapes fixating stabilizations and, instead of conceiving fixed, found objects, they are created in variation with contingencies. Nomadic science occupies a territory without appropriating

it and, in this way, does not come to replace models. Thus, an inventive science leaves open spaces, to be filled in by experience – it is not a question of ready-made knowledge, but willing to be affected, in flux, in *turmoil*.

As can be seen, the articles that work on the method of cartography in science education have as a common and fundamental point an epistemological critique of knowledge being considered a representation of a reality. This criticism, which permeated all the works found in different ways, does not seek to deny that thought and knowledge are based on representations of what is seen or perceived by the senses, but constantly recognizes that what is represented is still a version of the facts, not the facts themselves.

CONTRIBUTIONS TO SCIENTIFIC RESEARCH: INVENTIVE COGNITION AND CARTOGRAPHIC POSTURE

Science invents a device capable of, according to its point of view, operating the selection between invention and what “is nothing but invention”. (...) The experimental device, conceived to perform the separation between subject and object, appears as a political device, operating the hierarchy of inventions, or, rather, converting one of them into the only legitimate representation of the phenomenon in question.

Barros & Kastrup, 2015, pp. 54-55.

Although the intention is to capture the real, not even a photograph is a representation of reality: it still configures a cutout, a look, the choice of an angle. Scientific researches, even when admitting the relevance of subjectivities, end up fixing them, as if the admitted subjectivities could then be represented – simply. How are relationships, sensations, presences, encounters, crossings photographed? Do these emerge with experience or are they posted in the field ready to be “discovered” and “analyzed”? If we admit that they are emergencies, they cannot be fully objectified in situations that can be represented as a transposed reality, and it is convenient to recognize that subject and object co-create in the encounter.

In the same way that excluding the value of representation would also be a catch, establishing advocating for inventive cognition as *the* new truth, which takes its place, is a territory to be carefully avoided, a lurking trap because we are so immersed in the hegemonic cognitive model. The authors Oliveira (2012), Cavalcanti (2018), Miranda *et al.* (2018) and, notably, Cammarota and Clareto (2012) worked on this theme in their research and writings, questioning this will of truth that operates in the current scientific model (Foucault, 2014 [1970]). It is not about investigating which model works more than the other, but how our ways of knowing have circumscribed our possibilities of reinventing and building worlds. How to escape our attempts to *overcome* what is set and to continue creating models?

A non-dogmatic position, but a serene, firm position, of someone who is in a permanent state of search, open to change, insofar as he has long since ceased to be too sure of his certainties.

The more certain that I am right I feel convinced, the more I run the risk of *dogmatizing my posture, of freezing myself in it, of closing myself sectarianly in the cycle of my truth*.

This does not mean that the correct thing is to “roam around” irresponsibly, afraid to assert myself. It means *recognizing the historical character of my certainty*. The historicity of knowledge, its nature as a process in permanent becoming. It means recognizing knowledge as a social production, which results from action and reflection, from curiosity in a constant movement of search (Freire, 2001 [1993], p. 8, emphasis added).

The cartographic practice of working the attention and posture of researchers also crosses the work found, which sought to embody the procedural perspective of the field, access the experience in its uniqueness and take risks in non-constituted processes (Passos & Kastrup, 2013). This possibility of creating worlds integrates cartography as a method, taking research as an intervention (Cammarota & Clareto, 2012; Cintra *et al.*, 2017; Miranda *et al.*, 2018) and the plane of experience as a plane of production, displacements and inter-

ference for everyone involved, in an attitude of diving in the field. So that the access to the emerging experience is not just a theory, but that it becomes a fundamental research device, there is no need for apathy or even the distraction of those who observe, investigate and participate in the researched process. Under the cartographic bias, an active interest in everything that happens is required, so as not to choose an aspect to look at, but rather to try to get an impression of the whole – that is not why the details can be overlooked. For example, when visiting a group of students, the intention is to perceive the networks of relationships present there, taking into account cultural, political, social and subjective aspects in question, which are revealed in the speeches, views between students and/or between them and they and the educator present, in addition to the new relationships produced between these actors and the researchers. This posture was particularly evident in the works of Cammarota and Clareto (2012), Oliveira (2012), Kasper (2014) and Miranda *et al.* (2018).

In the beginning, the moving forces affect the perceptual consciousness, which is in theory invested by a concentrated and open attention. However, the importance of reflected consciousness, which works with intelligence and works as a second consciousness, is not discarded. It never hurts to remember that the second should not freeze or distort the first. It should not flatten out the roughness or trim the loose ends of perceptive consciousness, but, on the contrary, intensify, unfold and enlarge them (Passos & Kastrup, 2013, p. 404).

Betting on singularities, more than on the search for results that can be generalized, is also a frequent contribution to scientific research, a discussion present in the works of Cammarota and Clareto (2012), Oliveira (2012), Kasper (2014), Miranda *et al.* (2018) and Ramos and Brito (2018). Considering research as a space for the performance of an instrumented observer who *describes* the “reality seen”, reflecting it through theoretical frameworks, would reinforce a certain policy of cognition that, abdicating the singularities of situations and the inventive and creative potential that each circumstance and each experience can allow, ends up taking the events as “particular cases of general systems” (Alvarez & Passos, 2015).

One of these ways of researching aims at the path that goes from the concrete to the abstract, from the particular to the general. Such a position ends up hierarchically separating the explanation of what is explained, who knows what is known, generating a disembodied point of view that flies over reality in a position of third-person observer (another research *ethos*). It tends to become an increasingly pure and clear discourse about something that appears increasingly detached from events. It is strange how we are used (*sic*) to call this knowledge (Alvarez & Passos, 2015, p. 142).

Accessing experience from a point of view that does not claim neutrality includes being able to set aside the observer’s point of view for a moment without losing the observation and, once again, taking it for yourself, embodying it. To be, in some way, a spokesperson for the experience that emerges from the research. This cartographic trail of unfocused concentration (Barros & Kastrup, 2015) is also a policy of cognition, which exercises in researchers the access and development of a “body sensitive to new problems”. Access to experience must also be made possible through writing, through the elaboration of what emerges in the encounter and the research experience itself.

CONTRIBUTIONS TO SCIENCE EDUCATION: “TEACHING REQUIRES METHODOLOGICAL RIGOR”⁵

I teach because I seek, because I asked, because I ask and I ask myself.

Freire, 1996, p. 14, emphasis added.

Seeking to deepen the bridges between the cartography method and education, we establish, in this section, some parallels with the Freirian pedagogical proposal, causing slippages between research and teaching to emerge. Therefore, we base ourselves on the Freirian proposal that teaching requires methodological rigor

(Freire, 1996), seeking to locate rigor in contrast to rigidity. We return, then, to issues raised in the introduction of this article: the scientific truths that make up dogmatic discourses and that rely on the authority of knowledge are configured through banking education (Barcellos, 2020). Thus, the cartographic findings that have been worked on so far will be intertwined with education, in its emancipatory power, especially the work of care, the understanding of the pedagogical act as an experience to be accessed, the appreciation of the singularities of the contexts, of male and female students, as well as the prioritization of processes in relation to goals, both in research and in education.

In one of his last writings, *Pedagogia da autonomia* (1996), Paulo Freire emphasizes the importance of methodical rigor for the act of teaching. Let us already make it clear that this is not about strict banking, austere or inflexible. Differently from rigidity – more suited to an authoritarian, hierarchical, silencing education – rigor, in Freire, is allied to freedom, dialogicity, creation and commitment (Streck, 2010). This commitment is related to immersing professional teaching practice in the investigation and transformation of the realities in which educators and students are inserted.

Teaching, from a Freirian perspective, requires research. Just as the method of cartography proposes a redefinition of the understanding of methodological rigor, guiding it towards the cultivation of attitudes, precision in attention and the refinement of the researcher's gaze, this bet by Paulo Freire calls attention to such cultivation in the act of educating, leading the pupil-educator in pursuit of knowable objects. The methodical rigor inserted there seeks to embody, in teaching practice, not only critical content, but to make the very act of teaching dialogical – the form, the method – to prevent what he calls “pretty [speaking] of dialectics and mechanistically thinking” (Freire, 1996, p. 14).

The search in the cartography method for equipping processuality, for enhancing, more than the goals, the means, the form and what emerges from the experience, also offers important contributions to science education in the sense of thinking about the curriculum. The current cognitive model conceives knowledge as cumulative and the curriculum, accordingly, becomes the basis of this model, in which curriculum content is the most important part of a class and, as discussed in the work of Ramos and Brito (2018), if specific skills related to this curriculum are not achieved, the learning process is considered failed or unfinished:

All of this ends up having consequences for the student and the teacher because the technicist tendency creates for the teacher the “important” role of executing the tasks and programs determined in books, textbooks, that is, to be a science teacher it is enough to have the control over certain theories to pass on to students and how to use certain materials in classes or labs; and the student memorizes as if learning were uniquely and exclusively linked to the words spoken by the teacher in a class. Learning is effectively linked to knowing how to do, knowing how to apply the concepts of science. Learning becomes a simple passage, in which one moves from not knowing to knowing science (Ramos & Brito, 2018, p. 9).

As also discussed in Kasper (2014), more especially by Oliveira (2012), the script of a meeting, of a class, must do without being a prescription, of being an end to be a means, being at the service of the process and what emerges from the meeting of the proposal with its realization. In this sense, lesson plans and contents, even though they are an important base, come alive when they begin to open up space-time to the interlocutions and correlations that emerge in the experience, in its uniqueness. Opening a path for the unpredictable, disinvesting control and accepting the unforeseen as part of the process are, at the same time, a challenge and a power.

As in cartography, the other participants actively validate and compose the creation of emerging knowledge, in a liberating perspective, students are not passive repositories of scientific content. Considering the uniqueness of subjects, contexts and encounters, as well as their historicity, is to resist an education that is *enculturation*, reproduction and repetition. It is to challenge canonical models and disinvest domination, opening up space for the unsubmissive production of knowledge and for the possibility of *being more*. We confabulate with Freire (2013) when he says that, upon realizing the conditioning of our perception, this perception is already transformed. Thus, instrumentalizing the cartographic attitude of disinvesting power is also investigating

power and its manifestations (including those that we usually update), in a cartographic practice in which “the practice of alterity is sought, so that its relationship with the object is horizontal, in the sense of being attentive to the exercise of power, knowledge and an attitude of domination over the other.” (Cintra *et al.* 2017, p. 50).

It is precisely in this sense that teaching is not limited to the “treatment” of the object or content, superficially done, but extends to the production of conditions in which learning critically is possible. And these conditions imply or require the presence of educators and learners, creators, instigators, restless, rigorously curious, humble, and persistent people (FREIRE, 1996, p.13).

As scientific education consolidates the so-called “scientific facts” as truths based on a presupposed objectivity, it alienates male and female students from understanding themselves as a fundamental part of the construction of whatever content may be. In this Freirian perspective of education, the value of a teaching practice is not restricted to the conviction that one or another scientific concept faithfully represents a given fact of reality, it is not limited to the efficient transmission of truths, but concerns the engagement that such practice produces, as well as the interest it raises in the questions it mobilizes: in order to sustain themselves, scientific truths demand a “social sharing”, a “cultivation of belonging” (Costa, 2011). Therefore, the knowledge in question must be presented as open and unfinished, and this implies a method of educating that accompanies this opening, an ethical posture of the educator that is rigorously emancipatory and vigilant – and not just theoretically critical.

The commitment is not with a certain theory to be “proven”, but with the unveiling of reality that, no matter how competent the exercise, will always be greater than the capacity to apprehend it. There is, in Freire’s theory, the *release of a rigor that transforms the means into an end*, often becoming an obstacle to understanding reality (Streck, 2010, p. 598, our emphasis).

The “epistemological curiosity”, so dear in a Freirian or emancipatory approach to science education, presupposes respect and encouragement to the student’s inventive and creative capacity (Freire, 1996). In this way, we emphasize once again the cartographic guidelines of conceiving knowledge not as a static or stable representation of reality, but as being constituted in the very experience of knowing, intimately supported by the invention and recreation of realities. In the same direction, the cultivation of practices and attitudes of researchers and researchers and, by reciprocity, of educators and educators, to pay attention to what emerges from the meeting, from access to experience, to enhance procedurality more than pre-established goals, is consistent with a scientific education that suspends normative models and controlled practices, which is enlivened in the encounter with different realities. The cartography method, taken as theoretical, epistemological, practical and, perhaps, ontological inspiration, lends to education in political sciences of cognition engaged with change, enhancing the emancipatory possibilities of scientific knowledge.

FINAL CONSIDERATIONS

[Life] is a dance, but a cosmic dance, and we want to reduce it to a ridiculous and utilitarian choreography. A biography: someone was born, did this, did that, grew up, founded a city, invented Fordism, made the revolution, made a rocket, went into space; this is all a ridiculous little story. Why do we insist on making life useful? We have to have the courage to be radically alive, and not bargain for survival.

Krenak, 2020, pp. 108-109.

Has the authoritarian dimension of science, in its proclamation of truths, gained the confidence of the general public when trying to shout louder? Have you collaborated with the acceptance of multiplicities and differences, opening space for other cosmogonies and ways of experiencing life? Western thought, supported by Cartesianism, refines ethnocentrism into egocentrism and vice versa and has been supporting excluding, dominating, imperialist worldviews, which define as inferior and subjugable what escapes or announces other possibilities, *the others*. The others, women, blacks, indigenous people, workers, children, peripheral people, neverthe-

less, continue to insist on being; they open up detours and their (mis)paths present deviant perspectives, which insist on asking: what if all Western culture and thought were admitted as nothing more than a point of view?

This survey sought to show some developments of cartographic research in science research and education, especially with regard to the questioning of representational cognitive policy, as well as the place of power in which the invention is located. In this way, cartography is placed not only as a methodology, but as a theoretical-epistemological contribution, also because it does not address these aspects in a separate or fragmented way. Assuming the excluding character of the current cognitive model - which in many aspects distances itself from life and subordinates knowledge, and which has historically established truths that are not always based on the so-called “objective facts”, but on the production of markedly Eurocentric standards and assumptions, which deny knowledge of marginal peoples and cosmologies (Grosfoguel, 2016; Rosa, Alves-Brito & Pinheiro, 2020; Takimoto, 2021) – the method of cartography proposes suspending accustomed parameters from the very way of knowing.

What paths could we open if we experimented? What possibilities present themselves when we come to ask ourselves what kind of existence is a discourse or set of ideas, rather than merely accepting or discarding them? The hegemonic ways of knowing, based on the expectation of a reality to be discovered, described and analyzed, are structured on parameters and premises that establish error and success – basic elements of current education models. It is a challenge to resist the postulation of knowledge “better” than the other, knowledge that “surpass” the other, in an arboreal and linear hierarchy. In this sense, the proposal of knowledge as an invention aims to expand the concept of cognition as representation and, in doing so, take into account the implications that the representational model carries with it, such as the hierarchy of truths and the destitution of divergent or marginal knowledge. Thus, this article was involved in digging out possibilities so that the method of cartography can occupy and gain space in the scientific world, incorporating other ways of knowing, get to know and managing research and knowledge, announcing unique elements to science education and to scientific research in general.

Engaging a science that does not become *enculturation*, silencing and alienation presupposes conceptual changes but, in particular, transformations in practices and methods. Cartography as a method intends to produce escapes from what is set, from larger narratives, from the automatic, from the colonized and colonizing perspective, destabilizing habits in science research and education. Through the instrumentalization of the look and the researcher-educator body, the vivification of knowledge and invention as a cognitive policy, it embodies knowing in experience and in the singularities of contexts, not only describing states of affairs and transmitting such descriptions, but accessing experiences, knowledge, insurgencies, affectations, integrating worlds and trajectories into scientific work. We understand that an emancipatory perspective of science expands into singular realities and multiplicities, building social sharing and common territories, not univocal, seeking to generate trust and cultivate belonging (Costa, 2020).

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NOTES

- 1 The Isabelle Stengers book to which the authors refer is *A invenção das ciências modernas*.
- 2 The work by Deleuze and Guattari that is being referred to here is *Mil Platôs*, v. 1.
- 3 “Originally, the concept ‘Rhizome’ - word of Greek origin *“rhysos”*, which means root - was used in botany and means that, in the structure of some plants, shoots can branch at any point, as well as thicken and transform into a bulb or tuber, which can function as a root, stalk or branch, regardless (*sic*) of its location on the plant.” (DIAS and NASSIF, 2013).
- 4 In a Freirian perspective of emancipatory education, by the way, the concept of “cultural invasion” is intended to challenge the superposition of a value system to a certain social group, especially in a pedagogical act, in order to *replace* a *mistaken* view with a *correct* one or *true* (Barcellos, 2020). This concept is in line with what we call, here, *enculturation*.
- 5 “Teaching requires methodical rigor” is a subtitle of the first chapter of the book *Pedagogia da Autonomia*, by Paulo Freire (1996).

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