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Hegemonic and counter-hegemonic discourses in science education from the perspective of a post-critical curriculum theory

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Abstract
This paper explores various theories of curriculum intending to provide a new approach—which we regard as a significant theoretical contribution—to examine the broad set of different discourses that have been shaping science education. We first introduce concepts and values that support traditional and critical curriculum theories and offer some examples of international science education discourses that could be in tune with each of these approaches. We then develop a post-critical perspective (Laclau, Emancipação e diferença, EdUERJ, Rio de Janeiro, 2011) on curriculum, with emphasis on discourse theory (Laclau and Mouffe, Hegemonía y estrategia socialista: hacia uma radicalización de la democracia, Siglo XXI, Madrid, 1987) and on categories such as discourse, articulation, nodal points, antagonism and hegemony, to identify hegemonic and counter-hegemonic discourses in the scope of Brazilian science education scholarship and teacher education. Our analysis suggests that articulations and nodal points such as scientific knowledge, method and assessment have been framing traditional curriculum features that boost the hegemony of *knowledge itself*. On the other hand, nodal points such as gender, society, nature, curriculum and power relations have been forging the critical curriculum perspective as a counter-hegemonic discourse in the struggle for the hegemony of *knowledge to do something*. Nonetheless, more important than this portrait is the disclosure that antihegemonic discourses can support researchers who work for reactivating contingency and new antagonisms to transform science education.

Keywords Curriculum theories · Post-critical theories · Science education scholarship · Hegemony · Antagonism

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Science education and curriculum theories: a promising encounter

The expressions science education and science teaching have been used interchangeably in research articles, names of journals, academic meetings and professional associations. Although the expression science education seems to be more assimilated by the literature, it hides the fact that much of science education research has actually been more dedicated to the investigation of science teaching and learning methods, especially when it comes to the teaching of Physics (Rezende, Ostermann and Ferraz 2009). These studies frequently relegate the curriculum to the role of content organizer, rarely paying attention to its intrinsic social, political and cultural aspects. Alice Lopes and Elizabeth Macedo (2004) acknowledge that in Brazil and other nations, studies in science curricula "have still focused preferentially on curricular proposals and new methodological approaches" (p. 9), thus disregarding education "as a field of cultural production, therefore intrinsically political and social" (p. 9).

The conception of science curriculum just as an accumulation of generalizable and specialized knowledge has been disseminated in Brazil by the Coordination of Improvement of Graduated Staff (CAPES), the government institution that rules graduate programs to include science education. The CAPES report (Brasil 2017) reveals the meanings attributed by the official authorities to science education research: "the programs focus on research […] on *teaching a certain content*, seeking interlocution with the *areas that generate the content* to be taught" […] "to build bridges between academic knowledge generated on *education and teaching* for its *application in educational products and processes in society*" (p. 1). The signifiers in italics illustrate the government's commitment primarily to science teaching, understood as science education research. The research sustained by CAPES aims to improve the teaching of science content by the interlocution with the scientific knowledge of researchers and education and teaching experts. The resultant knowledge would be applied in the production of instructional materials and in science teaching processes.

This formulation of objectives for science education research does not consider critical positioning in relation to science, technology or social and cultural processes, seeming to reinforce conservative educational ideologies by strictly focusing the production of knowledge on optimizing the process of teaching. The CAPES report employs the term knowledge as if it was the same as content and uses the term society meaning a place whose educational processes and products need to receive applications of knowledge.

Those considerations could be possibly enunciated by anyone who thoroughly examined the text from a discourse analysis point of view. We believe that curriculum theories can go further, providing powerful support to discuss social, economic, political and cultural aspects intrinsically involved in curriculum and therefore in education (Gallard Martínez, Pitts, Brkich Milton, Ramos de Robles 2018). Our approach sought to build on the main curriculum theories based on Brazilian theorists (e.g., Lopes and Macedo 2011) to bring them closer to science education as a contribution to analytical and theoretical advances in the field. We explore concepts and values that support traditional and critical curricular perspectives and then develop a post-critical perspective (Laclau 2011) on curriculum with emphasis on discourse theory (Laclau and Mouffe 1987). In our analysis, we emphasize categories such as discourse, articulation, nodal points, antagonism and hegemony to identify hegemonic and counter-hegemonic discourses in Brazilian science education research and teacher education proposals.

Traditional and critical curriculum theories

The traditional curriculum perspective aims to be just a neutral, scientific theory that does not question the *status quo* or the dominant knowledge, prioritizing technical and organizational issues (Silva 2000). Assuming the current model of society as desirable, traditional education—and science education—is based on the modern epistemological view, which according to Norbert Elias (1994) places the subject at the center of the act of knowledge and individualism as a way of living in society. From an operational point of view, this perspective is materialized through concepts like objectives, planning, methodology, teaching, learning and assessment, aiming to reach efficiency.

In this framework, knowledge is external to the subject "devoid of links with experience, with the contextual discursive flow, with dynamics that are not limited to disciplinary and/or scientific records" (Lopes 2015, p. 459). The idea that there is a universal knowledge to be transferred to the subjects and to society is central to the struggle to hegemonize the defense of *knowledge itself*, which relies on the "belief that scientific fields are sources of true knowledge" (Macedo 2016, p. 61).

A brief retrospective of the North American educational scenario in the twentieth century allows us to understand conceptions that have forged traditional curriculum theory. During the 1920s, in the midst of the process of industrialization and urbanization in the USA, when the forms of mass education were being discussed, John Bobbitt's book (in Silva 2000) was considered the founding milestone of the specialized field of curriculum studies. Bobbitt's work proposed that the school should function like any commercial or industrial enterprise. His traditional perspective advocated that the educational system should accurately state what its objectives would be, based on an examination of the skills necessary for students to effectively exercise the professional occupations of adult life. The idea of efficiency, which in the economics field aimed at the extreme rationalization of production and maximization of profit, was then transferred to school.

Bobbitt's curriculum model was consolidated in Ralph Tyler's (in Silva 2000) book, published in 1949. Tyler's technical rationality considers that a considerable part of curriculum efficacy depends on the good definition of educational objectives (Lopes and Macedo 2011). These objectives must be formulated in terms of desirable behavior, explaining a behavioral orientation of traditional curriculum that exerted a strong influence in the USA and in Brazil in the 1960s (Silva 2000). The evaluation of learning effectiveness is the last step of curriculum planning and aims to determine to which extent educational objectives have been achieved.

Science education has suffered a great impact through traditional curriculum theory. The solution of educational problems has been considered as being only methodological, ignoring the broader social context in which the school is situated as well as not problematizing the curriculum. As Décio Auler (2007) points out, assuming the voice of science education researchers:

> Thus, for a long time, we bet that the solution of problems in the educational field would be in the methodological field, a mark given almost exclusively by cognitive psychology, then isolating the school from the larger social context. Thus, in the last decades, something profound remained untouchable, beyond the reach of a critical reflection: the curriculum. (Translated by the authors) (p. 174)

In contrast to traditional curriculum theory, which took the *status quo* as the desirable reference, critical theories of education contest precisely the nature, goals, approaches of

existing social and educational arrangements and aim at the emancipation of subjects. In this perspective, an important framework is what has been called theories of reproduction, developed mainly in the 1970s of the last century. These are Marxist theories that include various works in sociology field, such as Louis Althusser's theory (in Lopes and Macedo 2011), which, from the concept of state ideological apparatuses, points out the double character of the school's performance in the maintenance of the social structure. On the one hand, it acts directly in the formation of the labor force, and on the other, it contributes indirectly to differently diffuse ideology, functioning as a mechanism for co-opting the different classes (Lopes and Macedo 2011).

However, criticism of the capitalist school was not limited to Marxist analysis. For Pierre Bourdieu and Jean-Claude Passeron (in Silva 2000), the functioning of the school is not deduced from the functioning of economy: culture functions as an economy, which can be demonstrated through the concept of cultural capital. The dominant culture, which gives material and symbolic advantages to the person who possesses it, will constitute the necessary cultural capital (Silva 2000). In this sense, cultural reproduction operates in a similar way to economic reproduction in that the cultural capital of the ruling class, unequally distributed, favors to those who possess it and, thereby, perpetuates the inequality of that distribution (Lopes and Macedo 2011). In the sense of broadening the notion of reproduction, Michael Apple (in Lopes and Macedo 2011) is concerned with how school curricula (re)creates the ideological hegemony of particular groups within society and advocates the need for looking more closely at school, which is an issue not taken up by the reproductivists (Lopes and Macedo 2011).

The traditional curriculum theory was also questioned by the critical theory formulated by the Frankfurt School, based on the analysis of the role of economic and political structures in cultural and social reproduction through education and curriculum. The emphasis on efficiency and administrative rationality, espoused by traditional curriculum theory, would reflect the domination of capitalism over education and curriculum, thus contributing to the reproduction of class inequalities (Silva 2000).

Henry Giroux (in Silva 2000) formulates alternative bases to overcome the pessimism and immobility suggested by the theories of reproduction. Giroux (in Silva 2000) argues that education and curriculum are forms of domination and control, but he also calls attention to mediations and actions of opposition and resistance in school. By canalizing the political potential of resistance from students and teachers, it would be possible to develop a critical curriculum that would make people aware of the control and power exercised by social structures, which would emancipate them. Giroux uses the concept of voice to give students an active role and to point out the need to build a space in which they can be heard. According to Silva (2000), there is a recognized influence of Paulo Freire on Giroux's work for his emphasis on the relationship between education and power, and for the importance given to the participation of students in building the meanings of the pedagogical act.

Paulo Freire, a Brazilian scholar whose work is recognized in many countries, is considered a critical educator. His educational method aimed for the emancipation of peasants and adult workers oppressed by their social and cultural condition. In order to promote consciousness, Freire's (1987) pedagogy opposes what he calls banking education, in which "the learners are the depositaries and the educator the depositor" (p. 58). In Freire's (1987) proposal, as in the register of critical theories, individual emancipation implies the confrontation against all forms of oppression and social inequality. The association between individual emancipation and social emancipation produces a reconfiguration of the political role of education, making it committed to the struggle against social inequality.

It is possible to approximate the sociocultural perspective put forward by Jay Lemke (2001) for scientific education to critical educational theory, as the author argues that such an approach should not only focus on the analysis of sociocultural, but also on political aspects of science education. A critical approach can be noted when an author denounces the traditional underpinning of science education research based on science canonic epistemologists and cognitive psychologists and attributes to the neo-Vygotskian studies, the origin of a sociocultural perspective, incorporating the notion of learning in the community which involves power relations and sociocultural differences.

Although not explicitly committed to critical curriculum theory, Lemke (2006) made clear his anti-hegemonic position by accusing traditional science education of being driven by political interests geared toward the formation of a scientifically prepared workforce. The science curriculum for this purpose leaves much of the population out, while moving away from issues related to social reality and the daily concerns of students. Lemke (2006) advocates that science education should be reoriented to social problems—including social injustice—which will have to be faced by all humankind.

Gérard Fourez (1997) also imputes social and political criticism on science education curriculum. The author considers that science curricular proposals can play opposite roles: to prepare a skilled labor force or act on the autonomy of the individual. Science teachers should then find their way among these purposes and analyze ideological assumptions of curricula. Fourez (1997) considers that contact with the human and social sciences discourses becomes central and should be seen as pivotal in the scope of teacher education. With such a background, researchers and teachers working with science education should seek to understand how the curriculum responds to social issues and how it incorporates ideological representations of science, of the world and of society, which would provide a sound reflection on relations between science and society.

It is possible to attribute the emergence in several countries of more critical approaches in science education to the aggravation of environmental problems in the late 1970s. These approaches were geared specifically to question science and its relation to technology and to society (Aikenhead 1994) and were known as the science–technology–society (STS) curriculum movement. This orientation has been playing, a critical role in science education, as it continues inspiring research and curricular activities on environmental and other social problems and their relationships with science and technology. For example, in Brazil, the STS approach has been at times used in articulating Paulo Freire's ideas, which usually gives a more critical direction to the project. However, if the emphasis is more on Freirean methodology than on the author's political ideas, the critical purposes of STS can be weakened. The mere methodological appropriation tends to produce slips of the political meaning of Freirean thought, rendering it a conservative tone. The socio-scientific issues (SSI) approach in science education can be seen as a continuity of the STS paradigm in what is referred to as a critical emphasis, but it can go beyond (Zeidler, Sadler, Simmons and Howes 2005) as it intends to understand how these issues reflect moral principles involved in the physical and social world.

Unlike the STS movement, which emerged in a context marked by criticism of the scientific and technological model, the term scientific literacy was born by social pressures exerted by different groups of social actors, who attributed to this expression different purposes and conceptual definitions. International research on scientific literacy has prospered, with more or less critical shades that depend on the emphasis given to science learning in detriment of developing approaches aiming at a critical citizenry.

In Brazil, scientific literacy can specifically assume a critical bias as the term literacy carries an intrinsic relationship with social practice (Soares 1998). Thus, the expression scientific

literacy inherits an alternative sense, which emphasizes the social function of scientific education. Wildson dos Santos (2007) proposes that the processes of scientific literacy makes it possible to understand science–technology–society relations and to discuss the scientific and technological development model. The understanding of basic principles of everyday phenomena will create the necessary competences to make decisions either in health issues, intake of industrialized products or in environmental preservation. In all these examples, scientific knowledge is understood as a form of cultural capital to be mobilized in social practice. dos Santos's conception could be approximated to what is defended by Rüdiger Laugksch (2000) as scientific literacy with a social function.

However, scientific literacy with a social function and its broader competences has been approximated to curricular policies aligned to the new configurations of social organization and work. Both discourses imply competences to act in concrete situations, considered by Macedo (2016) as *knowledge to do something*, and have *knowledge itself* as its antagonist.

Contemporarily, other pressures have been acting upon science education. Information and communication technologies, economic globalization and increased migratory flows, among other factors, have been giving the world a strong multicultural outlook. In this scenario, the exclusion of any culture from a pretentious general culture is to be condemned by the various social movements—ethnic, gender, and religious—which further complicates the dispute over what to teach and how to represent the different cultures in the curriculum (Lopes and Macedo 2011) to the extent that it is a social conflict arena. Proposals to deal with the multicultural aspect of society and school are on the horizon of liberal policies that seek to create solutions to problems generated by the inclusion of previously excluded groups. The liberal perspective proposes a multicultural curriculum based on the ideas of tolerance and respect, which imply superiority by the one who tolerates or forces some cultural difference to be respected.

Critical educational theories respond to the multicultural character of society differently, by promoting interaction, negotiation and conflictual consensus among the diverse cultures (Lopes and Macedo 2011), putting into question the idea of the curriculum being informed by a common culture. Peter McLaren (in Lopes and Macedo 2011) defends critical multicultural perspectives, and recommends a cultural negotiation in a contested terrain, marked by history, power, culture and ideology. His proposal involves modifying the culturally constructed meanings, opening the possibility to transform social and historical relations by the action of individuals.

The seminal paper by William Stanley and Nancy Brickhouse (1994) opened a significant debate about multiculturalism in science education, emphasizing the conflict between the universalist and the multiculturalist views of science (e.g., Cobern and Loving 2001). Since then, new theoretical positions which defend epistemological diversity have been more accepted, and thus, the discussion has shifted to the kind of relationship that would exist between different types of knowledge (e.g., Alsop and Fawcet 2010). The incorporation of post-colonial references, although still underrepresented, introduces in the multicultural debate the relations of power and concepts such as borders, Eurocentrism, decolonization and interculturality (Carter 2004, 2010) that allow the understanding of political and ideological aspects involved in science and in science education.

The post-critical curriculum theories

The term post-critical theories have been used in the field of curriculum to refer to theories that question the assumptions of critical theories, which, marked by the influences of Marxism and the Frankfurt School, investigate relations of education with power and ideology. This set of theories includes post-structural, post-colonial, postmodern, post-foundational and post-Marxist studies. Although these theories have their own objects and struggles, they share the critique of structural thinking. According to Lopes (2013), post-critical studies are currently hegemonic in the field of curriculum, causing more and more critical thinking to be challenged by post-critical reflections.

In a strict sense, the critiques of structural thought occur in the scope of linguistics and operate in what has been called a linguistic turn. According to Silva (1994), this process displaces the subject of humanism and its consciousness from the center of the social world, replacing humans with the set of linguistic devices by which *reality* is defined. In post-structuralism, the very nature of language is also redefined, ceasing to be seen "as a neutral and transparent vehicle for representing reality, but as an integral and central part of its own definition and constitution" (Silva 1994, p. 248). In this redefinition, language is also no longer seen as stable in relation to a particular meaning, to which it would correspond univocally, but being regarded as constantly flowing, "never being able to definitively capture any meaning that would precede it and to which it would be unequivocally tied" (Silva 1994, p. 248).

In a broad sense, post-critical studies encompass all approaches that even not taking linguistics as a reference have the criticism of a structure whether cognitive, economic or social as determinant. Such studies are included in the post-critical label because the prefix *post* has, in this case, the sense of reconfiguration or abandonment to the essentialist axioms (Laclau and Mouffe 1987), which implies the questioning of the basis of a given school of thought, be it structuralism, modernism, foundationalism, colonialism or Marxism.

Post-structuralism and postmodernism perspectives, instead of highlighting matters of power as in critical education, put under suspicion the whole modern Western philosophical and scientific tradition as Eurocentric, phallocentric and racist, to include the ideas of reason, progress and science (Silva 1993). The terms postmodernism and post-structuralism are then identified with the same "set of contestations to the foundations of thought, philosophy, social sciences, and the arts" (Silva 1994, p. 247). Post-foundationalism rejects the notion that foundations are based on some rational principle. Specifically, post-foundationalism works with the idea of contingent and unstable foundations, which presupposes some fixation, although temporary.

Aligned to post-critical theories, Ernesto Laclau (2011) eliminates policy conceived as an intervention that is aimed at developing a common goal to all contexts. According to Laclau (2011), politics is the exercise of the decision that constitutes us as subjects, and this decision is always contingent, always presenting itself as an option in an unforeseen set of possibilities. Assuming this view, it is impossible to have fixed foundations, as meanings are constantly in dispute, and so we are constantly trying to define certain concepts, such as justice, equality or emancipation.

The dimension of foundation is not abandoned, but only the possibility that any foundation is given before the political game. Laclau (2011) admits that the particularity both denies and requires totality or foundation: totality is required as a constitutive fault that constantly forces the individual to assume a universal role, which, however, can only be

precarious and non-sutured. From this perspective, Laclau (2011) comprehends democratic politics as a succession of particular identities that try to assume universal tasks, although not managing to hide their self-interest. In this attempt, although contingent and precarious, a hegemonic discourse is created, which antagonizes another one. It is precisely the incompleteness and precariousness of hegemonic discourse that will make democracy possible.

In order to elaborate the concept of hegemony, Laclau and Mouffe (1987) consider the opening of the social as constitutive and the various social orders as precarious. Here it is necessary to differentiate the *social* from society. In the authors' theoretical construction, the concept of a sutured and self-defined society is substituted by the concept of social where there is no single underlying principle that institutes the whole field of differences. In the social, the tension between interiority and exteriority is pointed out as a condition of all social practice, since there is no possibility of total interiority or exteriority. It is in this precarious terrain, which denies every essentialist approach to social relations, where the social is constituted and where the precarious character of identities is also affirmed.

The concept of articulation plays an important role in the social. Laclau and Mouffe (1987) understand articulation as "every practice that establishes such a relation between elements that their identity is modified as a result of this practice" (p. 176). This practice works as a fundamental step in the production of hegemonic discourses. Articulation practice is necessary to produce a structured totality—which the authors call a discourse—that, however, is never fully accomplished. The discourse or discursive formation presents regularity in its dispersion and can be thought as a set of differential positions. In this type of articulated totality, all identity is relational and the positions of subject are dispersed. On the other hand, the practice of articulation as a fixation of a system of differences is seen not only as a linguistic phenomenon, but also as a practice that "must go through all the material thickness of institutions, rituals, practices of various orders, through which a discursive formation is structured" (p. 185).

Accepting that a discursive totality does not exist in the form of a given and delimited positivity, the relational logic of discourse is an incomplete logic impregnated by contingency, a place where social identities can never be fully constituted. Neither absolute fixation of identity nor absolute non-fixation is possible, but there are partial fixations around privileged discursive points that the authors call nodal points. In a system with these features, the elements of discourse are floating signifiers and this floating character penetrates into all social identity. Considering also the incompleteness of all discursive formation, the ambiguity of the signifier, its non-fixation to any meaning, all these characteristics can exist only to the extent that there is polysemy, which disarticulates the discursive structure. In these circumstances, the practice of articulation consists in "the construction of nodal points which partially fix meaning; and the partial character of this fixation proceeds from the openness of the social, a result, in its turn, of the constant overflowing of every discourse" (Laclau and Mouffe 1987, p. 193). The hegemonic struggle then seeks to "temporarily fix and universalize a particular sense and simultaneously produce its antagonistic other, expelling it from the hegemonic chain" (Gabriel 2016, p. 113). Symmetrically, investing in anti-hegemonic struggles means reactivating contingency through the production of other universals and antagonisms created by other discursive articulations.

Such conceptions of the social and social identities relate to other post-critical authors, such as Stuart Hall (2012), for whom identity can only be understood as temporarily forged in, or through, the difference and is constantly reworked by the processes of exclusion/differentiation. So, identities are "points of temporary attachment to the subject positions which discursive practices construct for us" (p. 112). Differences such as cultural,

religious, gender and race, as examples, are constructed discursively and then disseminated in the social. But considering the openness of the social and of all discourse, it is not possible in post-critical analysis to totally fix positions in a closed system of differences, under the risk of transforming the dispersion of subject positions into an effective separation between them, which would be incompatible with this theoretical framework. For this reason, Laclau and Mouffe (1987) make it clear that this type of analysis cannot prescind ways of overdetermination of some positions by others, nor from the contingent character of all necessity, which is inherent in all discursive difference. Necessity understood here not as a basis, but as an effort to establish differences within the discourse.

A post-critical reading of the curriculum

From a post-critical/post-foundationalism perspective, the idea of curriculum as knowledge selected from a common culture is put under suspicion (Lopes 2013), as long as knowledge becomes the result of struggles for signification. The legitimacy of knowledge and the universality of science are contested, while acts of power that contextually modifies the meaning of knowledge are stressed. In this scenario, the demands of difference, such as gender, ethnicity, region and religion, as examples, are more significant, leading to the defense of a multicultural curriculum that allows rethinking hierarchies and oppressive power relations, breaking with Eurocentric and colonialist systems.

The post-critical reading of the curriculum could lead to the conclusion that the struggle for utopia sought by critical theories would be abandoned in the name of a relativistic curriculum guided by contingent differences. However, contrary to this position, Lopes (2013) argues that in a post-critical perspective, the space for political struggle in the contemporary context is widened, as two dimensions of political activity coexist: the one which is instituted by the institutions and rules of social life, and the one which institutes activities present in all actions that constitute the social. In both kinds of practices, we are always practicing "the exercise of the decision that constitutes us as subjects" (Lopes 2013, p. 20).

In the implementation of curriculum policies, e.g., the Common Curricular National Base (Brasil 2018) of Brazil or Science, Technology, Engineering and Mathematics Education of the USA, the acts and institutions that sought to regulate the curriculum coexist with the political activities of the subjects that construct the curriculum in the daily life of school. Since there are no stable prior rules that undoubtedly define the policy, every political decision is always both contingent and an option in an unforeseen set of possibilities.

Recent curriculum policies, in Brazil or in the USA, can be clearly criticized for placing prime value on performativity (Zouda 2018). However, from a post-foundational point of view, the criticism relates to the idea that the social purposes foreseen in these documents, if discursively understood, no longer have a rational, calculated basis capable of sustaining a given choice. In this reading, the purpose of setting identities would be abandoned or at least replaced by contextual and localized agendas that could not be enumerated. Thus, the option for a given social purpose, the enunciation of this purpose and its defense, would be inserted in the sphere of politics and defined in power relations. Under such conditions, there will be no curriculum fully produced in any given direction, whatever it may be. Different discourses will always be disputing the significance of what curriculum is and producing unforeseen meanings, implying that such a common curricular basis is never actually instituted.

Nonetheless, even considering the project of a national curriculum as an impossibility, Lopes (2015) warns that a proposal to unify a common curricular project presupposes

foundations that end up harming or impeding alternative projects that have the potential to expand democratic meanings. The attempt to impose a curricular policy at national level also ends up carrying a "homogenizing and negative image of the school" (Lopes 2015, p. 458), as this policy is made to fill educational gaps perceived by policy makers. Another aspect pointed out by the author is the fact that the common curriculum base also impairs the development of local projects by becoming a unique reference and thus re-signifying them as non-priority and non-related to the knowledge considered essential.

The precarious nature of identities aligned to the post-critical curriculum gains relevance as well as a reflection on teacher education because formative processes such as teacher education and the alleged identities predicted for the subjects are directly impacted. To the extent that in the post-foundational registers the idea of a conscious, centered subject with a fixed identity is put under suspicion, any training project becomes impossible, and any policy is doomed to failure. It is not possible to establish an intersubjective relation with the other in order to have control over the process of his/her identification. Any project of a univocal signification has no way of being successful. The identity project, which a teacher education course can propose, is impossible, since in the context of post-foundational theories there are no full identities. A critical project, for example, that aims at an emancipated and conscious subject is thus destabilized, as the very concept of emancipation as a total and permanent condition is also deconstructed.

In the context of teacher education, the training possibilities are also contingent and contextual in a game of unpredictability, uncertainty and interpretation. Possible teacher education is then conceived as a contingent necessity, as "an activity in which both communication and political processes are mutually intertwined" (Lopes and Borges 2015, p. 499), thus becoming a process of radical contextualization. This post-critical reading of teacher education as well as of curriculum does not promote demobilization; on the contrary, it results in hyper-politicization, which implies the commitment and responsibility for political and contextual actions.

Hegemonic and counter-hegemonic discourses in Brazilian science education

From a post-critical perspective, science education scholarship and teacher education have been experienced as a space of permanent conflict for the hegemonization of particular signifiers elevated to a universal place in the midst of political struggles for meaning. In these processes, different hegemonic senses are built through articulations and nodal points; likewise, other senses emerge as antagonistic. In this section, we intend to make an analytical effort to uncover particular discursive articulations and nodal points, as well as processes of meaning fixation and antagonisms among a range of discursive possibilities that constitute Brazilian science education scholarship and teacher education.

Hegemonic and counter-hegemonic discourses in science education scholarship of Brazil

We examined articles published in "Ciência & Educação," one of the most influential Brazilian journals on science education research. This journal publishes four issues per year, containing 15 articles each. We scrutinized the signifiers used in the titles of 120 articles, randomly selected, published in a set of eight issues, one from each

year, in the period from 2010 to 2017. We concluded that the signifiers used in 94% of the titles were related to traditional curriculum theory. A few examples of articles are briefly described aiming to illustrate articulations and nodal points associated with the traditional curriculum perspective although the authors did not explicitly assume this commitment.

Giovanna Silva, Mara Braibante, Hugo Braibante, Maurícius Pazinato and Marcele Trevisan (2014) describe a workshop about Bohr's atomic model at the high school level and an evaluation of this methodology. By articulating a specific methodological proposal, a predetermined content and the results of its implementation, the study aligns—although implicitly—to the traditional curriculum theory. Lílian Bergqvist and Stella Prestes (2014) describe a kit about paleontology for K-12 level students following a structure similar to the one used by Silva, Braibante, Braibante, Pazinato and Trevisan (2014). In the description of the instructional material, it was possible to perceive the strong influence of scientific knowledge, Geology, and a poor relation to theoretical frameworks of science education research. The discursive articulation of hands-on experiments to the solution of science education problems and the use of terms such as *efficiency* and *efficacy* related to materials and to learning reflects the implicit connection of this study to traditional curriculum theory. Paulo Bretones and Maurício Compiani (2011) report on an astronomy course for K-12 science and geography teachers and the assessment of the conceptual evolution of these teachers regarding science content discussed in the course. The discursive articulation between teacher education, content learning and the teachers' conceptual evolution allows a cognitive perspective as well as a traditional curriculum theory approach to the study.

Those nodal points—scientific knowledge, method, assessment—and the discursive articulations with science education have been framing the traditional influence on science education scholarship, reinforcing the contingent hegemony of *knowledge itself*. The adherence to this theory is not explicit, functioning as common sense, something naturalized by researchers. It was possible to observe, in these examples, discursive articulations with the traditional bias and at the same time the absence of articulations with critical views. These latter articulations were expelled from the discourse.

The analysis also identified overdetermination of meanings, which made the article as a whole lose its critical character. Juliana Mundim and Wildson dos Santos's (2012) study, for example, could be configured as critical since it deals with the approach of socio-scientific issues. However, we realized that the articulation of scientific concepts with social issues was reduced to the contextualization of scientific concepts. The discursive articulation equated the purpose of science education only to the learning of scientific content while society was understood only as a locus for the application of scientific concepts.

On the other hand, it was possible to perceive discursive articulations clearly aligned with the critical curriculum perspective. Fabiane da Silva and Paula Ribeiro (2014) investigated the academic and professional trajectory of Brazilian female scientists and concluded that it is framed by masculine values, standards and conditions that restrict, hinder and direct their participation in science. The object of their study, clearly related to critical curriculum studies, led to discursive articulations between concepts of gender and power, revealing male prejudices and restrictions on the participation of women in science. César da Costa and Carlos Loureiro (2015) develop under the rubric of historical-dialectical materialism, the conceptual and methodological basis of critical environmental education and its links to interdisciplinary studies, indicating epistemological implications. The discursive articulation between society and nature is placed as central, in order to avoid a simplified, fragmented and depoliticized environmental debate.

Gleice Ferraz and Flavia Rezende (2014) investigated the discursive appropriation of Brazilian physics curriculum by five high school teachers who worked in different regions of the country. The analysis of the teachers' discourses showed articulations between the nodal points physics curriculum and contextualization of concepts, which led the teachers to defend the Brazilian official curriculum. In a different perspective, the researchers used relations between curriculum and power to interpret teachers' discourses and to conclude that they overlooked critical curriculum perspectives, which prevented them from assuming an alternative position.

Nodal points such as gender, society, nature, curriculum and power relations were articulated with science education in these three studies. The critical curriculum perspective as a counter-hegemonic discourse confronts the supremacy of *knowledge itself* while builds articulations and new nodal points in the struggle for the hegemony of *knowledge to do something*.

Unlike the studies grounded in concepts related to traditional curriculum theory, which are implicitly guided by this framework, it became clear that the critical researcher is aware of the political role of his/her research, either by the theme he/she chooses to investigate, by critical authors he/she discusses or by the adherence to critical curriculum theory itself.

Hegemonic and counter-hegemonic discourses in science teacher education of Brazil

In this section, we discuss an emblematic case concerning the confrontation between traditional and critical perspectives—and also between *knowledge itself* and *knowledge to do something*—in science teacher education. The opposition between these frameworks became more noticeable in the Brazilian science education community after the publication of a theoretical article (Rezende and Ostermann 2015) that discussed a critical proposal of science teacher education and of another article (Moreira, Studart and Vianna 2016), which mentioned the former and defended a science teacher-training proposal.

Lately, the investment in in-service teacher education, proposed by the World Bank for developing countries, has privileged content knowledge (Maués 2011) over pedagogical knowledge. In Brazil, this policy was implemented by CAPES at the graduate level through professional master's courses in teacher education, and specifically in the Professional Master in Science Teaching (PMST). The disciplines offered in PMST courses emphasized scientific content, aiming to fulfill eventual teachers' science knowledge gaps or to provide advanced topics in science. The requirement of an instructional material developed by the teacher also reflects the influence of traditional curriculum theory.

The traditional teacher-training curriculum that supports PMST courses is a discursive formation, a hegemonic articulation that has as one of its main nodal points the defense of scientific content, negating its relations with the social, cultural, economic contexts. Technical rationality is implicit in the obligatory development of instructional material by the teachers guided by the application of specialized knowledge without considering multiple educational contexts.

Rezende and Ostermann (2015) have pointed out additional limitations of PMST courses based on Acácia Kuenzer's (2011) theoretical assumptions of a critical teacher education proposal. First of all, Kuenzer (2010) advocates that the objectives of teacher education would need to consider the social reality of Brazilian public high school students who are "young people living social and productive relations marked by exclusion, by the lack of a future project, by technological complexity and by the media" (p. 869).

Regarding the teacher education curriculum, Kuenzer (2011) states that it would be necessary to go beyond the specific content. She emphasizes the need for studies and practices that allow the teacher to "take ownership of the different forms of reading and interpretation of reality […] in particular, of philosophy, history, sociology and economy" (p. 684). Beyond technical rationality, the teacher would need to act in tune with the specific school context, selecting contents, organizing learning situations that promote the interpretation of reality and the transition from common sense to scientific behavior.

Rezende and Ostermann (2015) criticize PMST courses mainly for having the rationalist training model, which does not prepare the science teacher to reflect on the relations between education and society, curriculum policies and the aims of science teaching. From a counter-hegemonic perspective, the authors argue that it would be appropriate to investigate the current problems and choose theoretical and methodological frameworks according to school reality. They acknowledge the discursive articulation between science and the humanities, considering it crucial for a critical teacher education. This approach would be obligatory to lead the science teacher to identify the new demands of scientific education and the interests to which they are linked.

The critical proposal of science teacher education developed by Rezende and Ostermann (2015) provoked a contrary position among Brazilian scholars, confirming that critical discourse represented an antagonism to the hegemonic project. Marco Antonio Moreira, Nelson Studart and Deise Vianna (2016) bring standpoints posed by a Nobel Prize in physics—a discursive construction that already shows the defense of *knowledge itself* in science education—to introduce the description of the PMST courses. Scientific knowledge is the privileged nodal point in the description of the courses' objectives, of the curriculum, as well as of the supervisors' academic profiles. They literally present the main criticisms formulated by Rezende and Ostermann (2015) and disqualify them all, assuming that they are "commonplace, jargons from the academic discourse that is contrary to the PMST" (p. 4327–5). Moreira, Studart and Vianna conclude with no sound justification that could be a rejoinder to the critics and tautologically state that they will go on betting on the PMST courses because of their intrinsic value to science education.

Post-critical curriculum theories as a powerful tool to interpret and transform science education

Curriculum theories have provided conceptual tools that enabled us to characterize traditional science education as a reproducer of the status quo and a critical science education that contests a capitalist society. Post-critical curricular frameworks allowed us to interpret these possibilities as a struggle for meaning and hegemony.

In the perspective of a curriculum without fundamentals and an impossible teacher education, there can be no project fully delineated in any given direction, whatever it may be. Different discourses will always challenge the meaning of what is curriculum and teacher's education, producing unforeseen meanings from discursive articulations that make political decisions possible. Social justice, for example, as a concern of a science curriculum is only one of the many concerns that are disputed. Disputes of differing views of science education, more or less traditional, more or less critical are at work in educational institutions. In post-critical frameworks, whatever are the approaches carried out they will not be conducted for a unique societal project, but as contingent versions of scientific education.

The traditional and critical conceptions of science education continue to be legitimate and have been discursively identified here as antagonists. Our analysis made it possible to consider the traditional science curriculum as a hegemonic product of discursive articulations in defense of *knowledge itself* in both Brazilian science education scholarship and science teacher education at the graduate level.

Antagonist discourses on gender relations, critical environment education and discursive articulations between physics curriculum and power relations were also identified. The critical proposal for science teacher education advocated an integration of humanities in the curriculum, aiming to provide the teachers deeper conceptual tools to analyze educational reality. All these critical works implicitly defended *knowledge to do something*.

And, so what? The post-critical theories as a research framework allowed us to understand that discursive articulations and nodal points associated with traditional curriculum theory are hegemonic in Brazilian science education scholarship and some critical discourses are anti-hegemonic. We consider that more important than the production of this portrait is that the disclosure of anti-hegemonic discourses can encourage researchers to continue working for reactivating contingency and antagonisms created by alternative discursive articulations.

Going beyond the theoretical and empirical efforts carried out, we are concerned that the discourses which advocate *knowledge to do something* are being advanced to those which advocate *knowledge itself* in educational policies and in academic texts. We believe that the cooptation of the critical view in order to meet neoliberal demands (Macedo 2016) might jeopardize the democratic science educational project. The way to maintain antagonism and the struggle for democracy would be to radicalize the critical discourse defending a radical commitment to sociopolitical action, transforming science education.

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