

Physics education from the perspective of epistemic colonization: a decolonial lens from the Brazilian curriculum

O ensino de física a partir da perspectiva da colonização epistêmica: uma lente decolonial do currículo brasileiro

Carlos Mometti^{1*}, Tanja Tajmel², Maurício Pietrocola³

¹Doutorando em Programa de Pós-Graduação Interunidades em Ensino de Ciências, Faculdade de Educação da Universidade de São Paulo, Av. da Universidade, 308 - Cep.: 05508-040, Cidade Universitária - São Paulo/SP, Brasil.

²Centre for Engineering in Society, Gina Cody School of Engineering and Computer Science, Concordia University, 1515 St. Catherine West, Montreal, Quebec, H3G 2W1. Canada.

³Orientador em Programa de Pós-Graduação Interunidades em Ensino de Ciências, Faculdade de Educação da Universidade de São Paulo, Av. da Universidade, 308 - Cep.: 05508-040, Cidade Universitária - São Paulo/SP, Brasil.

*E-mail: carlosmometti@usp.br

Recibido el 15 de junio de 2021 | Aceptado el 1 de septiembre de 2021

Abstract

The present work aims to present a cut of research at the PhD level taking as the object of study the curriculum of Physics Education from Brazilian high school under the lens of decolonial theory. The hypotheses that guide this work are: (i) There is a form of colonization manifested through the episteme, (ii) Epistemic and cultural colonization lead to a reontologization of the subject and it takes place through power devices incorporated in the curriculum. Thus, it is hoped with this investigation to understand the cultural devices that act as a colonizing operator on the set of scientific and representational patterns materialized through the Physics curriculum in Brazil.

Keywords: Physics education; Curriculum; Decolonial theory.

Resumo

o presente trabalho tem como objetivo apresentar um recorte de pesquisa em nível de doutorado, tomando o currículo de Física brasileiro como objeto de estudo na perspectiva da teoria decolonial. As hipóteses que norteiam este trabalho são: (i) Existe uma forma de colonização que se manifesta por meio da episteme, (ii) As colonizações epistêmica e cultural levam a uma reontologização do sujeito e ocorre por meio de dispositivos de poder incorporados ao currículo. Assim, espera-se com esta pesquisa compreender os dispositivos culturais que atuam como operador colonizador no conjunto de padrões científicos e representacionais materializados por meio do currículo de Física no Brasil.

Palavras-chave: Ensino de Física; Currículo; Teoria decolonial.

www.revistas.unc.edu.ar/index.php/revistaEF

REVISTA DE ENSEÑANZA DE LA FÍSICA, Vol. 33, no. 2 (2021)

La evaluación del presente artículo estuvo a cargo de la organización de la XIV Conferencia Interamericana de Educación en Física

I. INTRODUCTION

Human activity in post-modernity has undergone substantial transformations with regard to the production of knowledge as, as well as its use. Thus, when analyzed from a historical perspective, we note that from the Enlightenment movement that took place in the 18th century, knowledge began a direction towards fragmentation, a fact characterized by the emergence of the first encyclopedia and, later, with the technical schools of Napoleonic France. The meaning of this, which came to be called technical, concerns the evolution of production and the means through which it becomes commercialized and capitalized.

Furthermore, the guiding axis of this movement is characterized by the emergence of industrial capitalism triggered by the application of scientific knowledge in the development of machines to produce more and better. Faced with this form of economic power represented by the newly emerging industrial class, politics should adjust to capital and, in this sense, the entire region of Central Europe begins its movement of socio-economic transformation.

In this way, we witness in the 21st century a movement of deep and intense discussions in the social, economic, and cultural spheres, resulting from capitalist evolution, highlighting gender discourses, power relations and the role of science in society, of social representation in science as well as the ontological aspects of the colonization of groups of greater power over those of lesser power.

One of these discussions, and which has been gaining strength in the last decade, mainly in Latin America, is the movement of resistance to the so-called colonial thinking, epistemologically based on the so-called theory of decolonization (Quijano, 1992; Mignolo and Walsh, 2018; Abdi, 2012). This category of thought, according to Mignolo and Walsh (2018) has molded, for centuries, the different peoples that make up the South American continent, taking their culture from it and promoting a process of forced enculturation, through colonizing psychology. The effects caused by this process, a theme that this work is concerned with discussing, are: breaking of the cultural bond of original peoples and loss of beliefs and values previously worshiped, fragmentation of habits and representations inherent to ethnic groups located in the same territory, imposition of a set of Americanized standards for the consumption of culture, information and eating habits and, which we will seek to defend in this work and which, in our view, is characterized by the most overwhelming of all, the process of *reontologization of the subject through epistemic colonization*.

In order to understand the impacts that the debate about decolonization brings to Science Education, especially to Physics Education, this article assumes as initial hypotheses: (i) there are cultural devices associated with the discipline of Physics in high school, which they materialize in the curriculum and influence the students' epistemic colonization process, (ii) The epistemic colonization process is triggered by cultural aspects manifested in teaching and that contribute to a second process, here assumed as reontologization. Such hypotheses motivated us to look for elements that evidence an epistemic colonization process, initially suggested through the scientific representation of the subjects submitted to the curriculum they use, as well as the cultural devices present in their enunciated discourse, which will be presented in this work.

II. THEORETICAL APPROACHES

The definitions of the concepts of coloniality and decoloniality essentially pass through the European historical line, since according to Quijano (1992) he defined in the 16th century what would become a new Europe, based on mercantilism and colonial exploitation. Thus, with the emergence of a bourgeois social group between the 14th and 15th centuries, Europe developed an internal movement for the formation of the so-called nation-states. The characterization of this formation is given by the delimitation of new geographic borders, the establishment of a language for a specific group of people and, mainly, the definition of centralizing political power, allied to religious or just economic power.

Thus, the French and Spanish territories stand out, later the Portuguese and the Italian grand ducats, in addition to the portion of northern Europe with the English kingdom. Until the period when there were the first agglomerations of territories for the constitution of a nation-state, the political-social organization of the aforementioned territories was the responsibility of the religious power allied to the feudal system. Thus, the market replaces the economic source that used to come from small-scale agriculture with intensive trade.

Furthermore, the European kingdoms already formed in the 16th century – Castilian, Portuguese, English and French – disputed among themselves the foreign markets, which until that moment were carried out only with the eastern part of the globe. Thus, with greater investments by European monarchies, a movement of expansion across the oceans begins, with the aim of discovering new political, economic and geographic possibilities.

At this point, we must stick to the fact that it was the change in the European economic system and the growing need for market expansion that forced, in a way, the search for new routes to the East, a fact that resulted in the arrival in America in 1492, or as it was called prior to the colonization process, in *Abya Yala*. According to the story told and reproduced in the southern part of the American continent, Europeans “discovered” America by chance. Now, this chance culminated in discovery not only geographically, but also with regard to the production and supply of raw material for the parent companies to produce consumer goods and return them to their consumer market. Therefore, a new story begins that of modern colonization.

In this sense, the appropriation by Europeans of lands on the American continent – highlighting its three parts here – was based on what Walsh and Mignolo (2018) and Quijano (1992, 2019) define as a *colonial matrix of power*. This matrix is constituted, in a way, by the set of social, economic, psychological and political procedures used to dominate a territory that was already dominated, that is, to colonize a space that was already occupied by other social groups: those called by 15th-century literature of indigenous peoples. In this way, from the colonial matrix of power, we can understand the process through which the peoples of the Americas were subjugated to the power of the white Europeans. Thus, we can say corroborating Quijano (1992, 2019) that there would be no modern Europe without the possession of the Americas in the 15th century.

So, there is a second concept allied to that of colonization, which is indicated by coloniality. According to Walsh and Mignolo (2018), Quijano (1992, 2019), colonization allowed white Europeans to constitute a new Western Europe in the 15th century, Europe seen as modern, which would develop and would be focused on its mercantile expansion. In this way, the same author's orient towards the *coloniality/modernity* dyad. Thus, this dyad concerns the colonial power matrix and is sustained by the exploration of new territories and the need to produce raw materials for metropolitan power.

In this way, the European colonialism that emerged in the 15th century and that took place between the end of the 18th century and the beginning of the 19th was replaced by coloniality, which is the result of a second economic process initiated with imperialism. Also, according to Quijano (1992, 2019) coloniality is a neologism, like modernity that originates from the word modern. Thus, this neologism indicates that, after the colonization process, colonial characteristics still remain, albeit in a culturally intensified way.

However, to explore new territories, which were already occupied by large populations, even forming empires such as the Aztecs, Mayans and Incas, in Central and South America, it was necessary to use military and political forces, as well as ideological and psychological forces. Furthermore, this process assumed the labor force as capital as its power supply. This means that from the need to explore new worlds, the workforce became essential for the maintenance of power, as well as for obtaining raw materials and managing markets by the metropolitan power. Coloniality operates through ideological force, and this maintains current markets.

Thus, another essential feature with regard to coloniality/modernity is the fact that it determines a new configuration of Western society, understood as globalization. The aspects that highlight the globalization of the colonial era are: (i) the scientific and religious justification of the notion of race and (ii) the hierarchical categories of ethnicity. Thus, colonization was not only related to the use of force, but also to the psychological and epistemic. In what refers to psychological colonization, we understand the insertion of values and beliefs linked to another culture over another, for example, the catechization promoted by the Jesuit Order in Brazil in social groups called Missions during the 16th and 17th centuries. Once a set defined as a pattern of behavior is established, the subject's psychology is altered, starting to re-signify itself as such.

For more than three hundred years in South America, millions of people were subjugated by the fact that they were black and, under the justification of Christian Europe, were exempt from soul and humanity. At this point, it corroborates Quijano's (2019) view that coloniality was only possible through the operation of two central axes: (i) the codification of the difference between conquerors and conquered in the idea of race and (ii) the constitution of a new structure of power control and its resources and products.

As for Abdi (2012), the colonizing project deprives the individual of his humanity, guaranteeing the colonizer to appropriate his psyche and configure cultural patterns that are perpetuated over generations. However, this colonial movement promoted crises in its own structure, causing resistance to arise from those who subjugated themselves and experience, even in the 21st century, colonizing, epistemological and ontological influences. Walsh and Mignolo (2018) and Quijano (1992, 2019) define this movement of resistance to the colonizing movement by decoloniality. In this sense, the decolonial movement is a call to the very existence of those who have always lived overshadowed by the power relations established by the colonizers.

Educational training is the operator through which the set of standards, beliefs and values of a society are transmitted, reproduced and transformed within a defined physical space within a considered period. In this mechanism, the standards, values and beliefs are periodically revisited and define both the psychological and ontological bases of the subjects belonging to the group. In this way, there is the production of historicity by these individuals through what we call culture.

Based on what was previously proposed, we assume by the hypothesis that the curriculum of scientific disciplines, especially Physics, brings cultural aspects that are embedded in an epistemic colonization process that is still in effect. This process, moreover, is characterized by the reproduction of cultural devices from a more powerful society over a less powerful group. In this perspective, we assume as power the capacity of the individual or specific groups to achieve their goals or assert their interests despite opposition or resistance (Giddens & Anton, 2017, p.299).

In this way, there would be no more adequate document than the curriculum to investigate how culture manifests itself, and which elements can show us some way to understand how epistemic colonization reaches students through the Teaching of Physics. With regard to the curriculum of Physics Education in Brazil, we highlight some elements that describe its evolution. Thus, all studies inherent to this area of knowledge are categorized as Science Teaching. Thus, according to Krasilchik (1987) and discussed by Carvalho and Vannuchi (1996), the evolution of Science Education in Brazil between the years 1950 and 1990 can be seen in Table I.

TABLE I. Evolution of the Science Education curriculum in Brazil in the period 1950 - 1990 according to Krasilchik (1987).

Year	1950 - 1960	1970	1980	1990
Mundial context	Cold War	Energy and oil crisis	Environmental problems	Technological competition
Brazilian Context	Industrialization / democratization	Dictatorship		Redemocratization
Objectives of teaching in elementary and high school	Form Brazilian elite	To form a citizen "morally"	Prepare worker	Train citizen and worker
Influences on teaching	New school movement	Behaviorism / Pragmatism	Behaviorism / Cognitivism	Cognitivism
Objectives of the renewal of Science Education	Broadcast updated information	Experiencing the scientific method	Think logically and critically	Science, Technology and Society Movement
Vision of Science in the school curriculum	Neutral activity emphasizing products	Historical evolution emphasizing the process	Product of the economic and social context	
Dominant recommended methodology	Laboratory - practice	Laboratory plus research discussion	Games and simulations. Problem solving.	
Institutions that influenced curriculum change	Professional scientific associations and government institutions	Curriculum Projects and International Organizations	Science Centers and Universities	Professional, scientific organizations and Universities

As described in Table I, from the 1950s onwards, Science Teaching in Brazil and, consequently, Physics Teaching was strongly influenced by the world context, especially with regard to the North America - South America axis.

III. METHODOLOGICAL FRAME

Firstly, the focus of this investigation is concentrated on secondary education and with regard to the Physics curriculum document. Thus, we limited our source of information for data extraction to the Brazilian high school physics curriculum. Thus, this work fits into the qualitative field of the interpretive type and is based on a documentary study.

To determine the curriculum to be used, we used three a priori categories extracted from the theory of decolonization proposed by Quijano (1992, 2019) and Mignolo and Walsh (2018), which are: (i) idea of ethnicity (race/ethnicity), (ii) cultural identity and (iii) economy/development. The first category refers to the ethnic diversity that makes up a social group, causing internal distinctions in order to promote racism and social power relations. The second concerns the ontological construction of the individual through the values and beliefs surrounding his environment, whether influenced or not by an external structure with greater power. Finally, the third category refers to economic development associated with the production of knowledge and, consequently, production-oriented technology. According to the three categories mentioned above, we chose to study the curriculum of the State of São Paulo, as it has ethnic diversity and the largest population in the country, as well as the greatest economic productivity.

For the transformation of information into analysis data, we used the Discourse Analysis (DA) method according to the perspective of Pêcheux (2014, 2015). Thus, the DA is carried out following the steps: (i) floating reading to identify the discursive surfaces, (ii) selection of the discursive surfaces that will be analyzed, (iii) selection of the discursive marks (words that act as a gateway to the discourse analyzed), (iv) identification of the discursive object (forgetting processes 1 and 2 of AD), (v) identification of the discursive process (are those meanings that are or are not possible for the discourse), (vi) discursive formation (mode how ideology is organized in language) and, finally, (vii) identification of ideological formation (raw material of discourse).

Once the ideological basis present in the selected discursive surface is identified, part II of the analysis begins, which counts with the help of the Critical Discourse Analysis (CDA), proposed by Van Dijk (1984, 1998) about the realization of an in-depth critical interpretation. According to Van Dijk (1984, 1998), every discourse brings an ideology that operates in society's attitudes and behaviors, for example, the discourses used by the marketing of commercial advertisements or the discourses used by governments in critical periods. Thus, through discourse, power "moves", that is, it operates actions in a social group.

As a second instrument of analysis, arising from the identification of the ideological bases that underlie the discourse, we propose the identification of an operator, defined by a cultural-epistemological operator. We understand by the cultural-epistemological operator the set of actions possibly triggered by the structural term in question. In summary, the analysis of discursive surfaces follows the order shown in Figure 1.

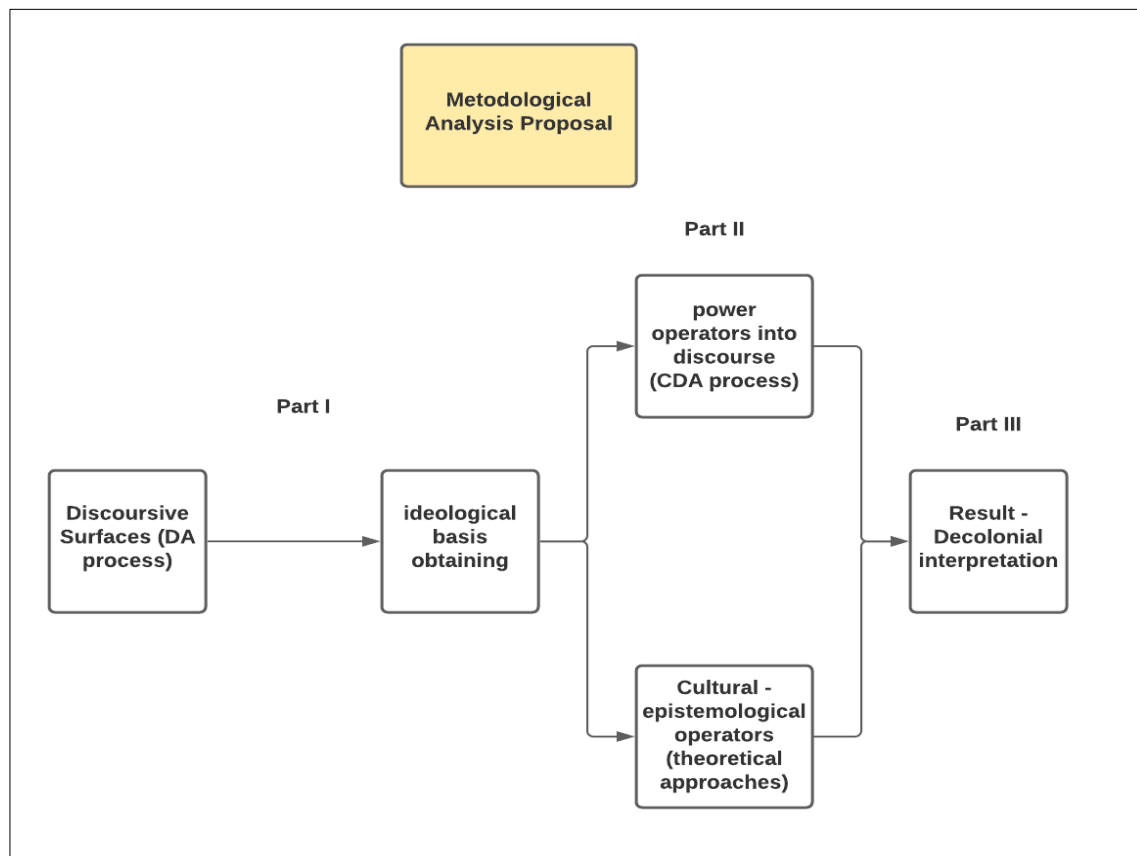


FIGURE 1. Scheme of the analysis methodology used in the research.

IV. DATA AND DISCUSSION

The curriculum used as a source of information in this work is structured on two pillars, which are defined as competencies and abilities. With regard to the students' learning objectives, the high school curriculum in the State of São Paulo presents some principles which focus on the development of actions aimed at overcoming the disciplinary fragmentation of knowledge, stimulating its contextualization and application in the real-life, to give meaning to what is learned (São Paulo, 2020, p. 32). The discursive surfaces analyzed from the Natural Sciences curriculum were extracted from the competencies that guide the Physics contents that must be worked on and are presented in Table II.

TABLE II. Discourse analysis results.

Analysis Elements	[Competence 1]	[Competence 2]	[Competence 3]
	Analyze natural phenomena and technological processes, based on the interactions and relationships between matter and energy, to propose individual and collective actions that improve production processes, minimize socio-environmental impacts and improve living conditions at the local, regional and global levels.	Analyze and use interpretations about the dynamics of Life, Earth, and the Cosmos to elaborate arguments, make predictions about the functioning and evolution of living beings and the Universe, and base and defend ethical and responsible decisions.	Investigate problem situations and evaluate applications of scientific and technological knowledge and their implications in the world, using procedures and languages specific to Natural Sciences, to propose solutions that consider local, regional, and/or global demands, and communicate their findings and conclusions to audiences varied, in different contexts and through different media and digital information and communication technologies (TDIC).
Discursive marks	Analyze Technological processes To propose actions Individual and collective Perfect production processes Improve living conditions	Analyze Use interpretations Dynamics Make arguments Make predictions To substantiate Defend ethical and responsible decisions	Investigate Evaluate applications of scientific and technological knowledge Applications in the world Natural Sciences procedures and languages Propose solutions Communicate your findings and conclusions Varied audiences Different contexts Different media
Discursive objects	To present the use of knowledge about the relationship between matter and energy for direct application.	Search for information about the physical, chemical, and biological nature to support decisions and guidelines for the collective.	Evidence that scientific literacy promotes the universalization of knowledge and the use of technology to solve problems.
Discursive process	To highlight the importance of understanding technological processes through physical knowledge for direct application in production and, consequently, in quality of life. It also includes the sense of sustainability, where it is produced by exploring nature and its relationship with globalization.	The meaning that the discourse conveys concerns the importance of knowledge as a necessary agent for decision-making in a social group. This means that guidance through sustained argumentation regulates ethical responsibility.	Scientific literacy is as necessary for understanding the contemporary world and, therefore, useful for solving society's problems. Universalization of scientific knowledge to disseminate arguments and construction of opinions using different media.
Discursive formation	Highlight the intrinsic relationship between the knowledge of physics associated with matter and energy, for its subsequent application in production processes. Also, highlight the relationship between the use of natural resources and development, hiding the ideas of consumption, quality of life, and standard of living.	The verbs highlighted on the surface show actions resulting from the incorporation of knowledge, attributing the sense of value and importance in society.	Through the appropriation of scientific language, the knowledge produced is disseminated and, thus, a connection of utilitarian character is established in society. In addition, living in the technological world is only possible through scientific literacy, which establishes an ontological character through knowledge.
Ideological formation	The discourse belongs to the capitalist ideology of productivity, increased efficiency of work and association of consumption - production - the quality of life.	The stated discourse belongs to the ideology that knowledge confers power and leadership in a social group.	The stated discourse belongs to the ideology that the universalization of scientific knowledge increases its credibility before society and, therefore, the sense of validity and utilitarianism. In addition, survival in the technological society and, therefore, inclusion in the production chain will only occur by obtaining scientific literacy.

In the discursive surface extracted from competence 1, the presence of two discourses is noted: knowledge as a value and applicability in work/production and that of sustainability. As we know, in many situations the idea of sustainability is associated with the notion of quality of life, providing values and standards that guide the behavior of individuals in today's consumer society. In this sense, we can say that there is notably a sense of value that operates the mechanism of this discourse, so we can identify it as the cultural-epistemological operator. As for the discourse on applied knowledge to "improve" production processes and, therefore, increase work efficiency, aiming at more production with fewer expenses - capitalist logic - we notice a power operator. Such an operator can be evidenced by the discursive mark "discursive processes" corroborated with the highlighted ideological formation. This means that the first competence that must be worked on in high school in the area of Natural Sciences brings the logic of efficiency and production through physical knowledge "matter" and "energy". Assuming what Quijano (1992, 2019) proposes, we perceive the manifestation of post-modern colonization aimed at the formation of individuals.

With regard to the discursive surface extracted from competence 2, it can be observed that knowledge, understood as a set of specific knowledge in the area of Natural Sciences, confers decision-making power on a social group. This can be evidenced by the discursive marks given by "defending ethical and responsible decisions", based on accumulated knowledge. In this way, we were able to notice that the number of verbs present on the discursive surface, according to Pêcheux (2014, 2015), shows the presence of behaviors that should or should not be incorporated through a cultural logic specific to the social environment. Thus, the cultural-epistemological operator that moves this discourse deals with patterns incorporated and possibly suggested through the acquisition of related Natural Science knowledge.

Finally, the discursive surface extracted from competence 3 brings three ideological bases in a single discourse. Initially, it proposes the universalization of scientific knowledge through different media, guaranteeing the diversity of people for its understanding. In this way, through the CDA on this ideological formation, we can identify that the objective of universalizing is to make certain content accessible and as recognizable as it can be and, consequently, guarantee a valid character for all who come into contact with it. Thus, the universalization of knowledge places it under evaluation, while at the same time conferring the transfer of values and beliefs, influencing society's choices and decision-making. This double mechanism can evidence the operator of power through scientific language. On the other hand, the second ideological formation present in the discourse in question points to an ontological construction characteristic of postmodernity: the intensive use of technologies in everyday life and its relationship with the definition of the self. Thus, no action is currently produced or carried out without the aid of some form of digital technology. Therefore, scientific literacy becomes essential to define a subject in their social group, as those who are not inserted in "this universe" will possibly be excluded from social participation, whether in interactions or in the international division of labor.

V. CONCLUSION

This article aims to present a study about epistemic colonization and its influences on the Brazilian physics curriculum, especially in the State of São Paulo, from the decolonizing lens as a theoretical perspective. Thus, the collected data were analyzed according to the Discourse Analysis proposed by Pêcheux (2014, 2015), the Critical Discourse Analysis and the proposal by Van Dijk (1984, 1998). With the first methodology, it was possible to obtain the ideological formations of the analyzed discursive surfaces, which were characterized by the competencies that define the analyzed Physics curriculum. We could see that ideological formation was centered on the following aspects: (i) logic of capitalist production, (ii) technique as an essential element to work and production and (iii) knowledge as an inducer of values and behavior. In this way, the evidenced ideological formations contribute to what we call epistemological colonization since through the competencies that define the curriculum reference teaching materials will be produced, which materialize a culture evidenced by the values and beliefs of the logic presented above.

Finally, through the Critical Discourse Analysis, we were able to highlight the operators of power, which showed knowledge as power and scientific language as an element of power. Thus, the discourse enunciated through the competencies of the Physics curriculum analyzed presents scientific literacy as necessary for both economic (capitalist) and social development, highlighting the quality of life as a discursive mark to convey a sense of "*science is learned for understand the world*", but actually what happens is "*you learn science to produce and consume the world*".

REFERENCES

- Abdi, A. (2012). *Decolonizing Philosophies of Education*. Rotterdam: Sense.
- Carvalho, A. & Vannucchi, A. (1996). O currículo de Física: inovações e tendências nos anos noventa. *Revista Investigações em Ensino de Ciências*, 1(1), 3-19.
- Giddens, A. & Sutton, P. W. (2015). *Conceitos essenciais de sociologia*. Trad. Claudia Freire. São Paulo: Unesp.
- Krasilchik, M. (1987). *O professor e o currículo das ciências*. São Paulo: E.P.U/EDUSP.
- Mignolo, W. & Walsh, C. (2018). *On decoloniality: concepts, analytics and praxis*. Durham: Duke University Press.
- Pêcheux, M. (2014). *Semântica e Discurso: uma crítica à afirmação do óbvio*. 5ª. ed. Campinas: Unicamp.
- Pêcheux, M. (2015). *Análise de Discurso*. 1ª. ed. Campinas: Pontes.
- Quijano, A. (1992). Colonialidad e Modernidad/Racionalidad. *Revista Perú Indígena*, 13(29), 11-20.
- Quijano, A. (2019). *Ensayos en torno a la colonialidad del poder*. 1ra. ed. Buenos Aires: Ediciones del Signo.
- São Paulo. (2020). *Currículo Paulista do Ensino Médio*. Available in: <https://efape.educacao.sp.gov.br/curriculopaulista/>
- Van Dijk, T. (1984). *Prejudice in discourse: an analysis of ethnic prejudice in cognition and conversation*. Amsterdam: John Benjamins.
- Van Dijk, T. (1998). *Ideology and Discourse: a multidisciplinary introduction*. Barcelona: Universidad Pompeu Fabra.
- Van Dijk, T. (2006). Ideology and discourse analysis. *Journal of Political Ideologies*, 11(2), 115-140. DOI: 10.1080/13569310600687908