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ARTICLE

EDUCATION FOR ETHNIC-RACIAL RELATIONS: AN ESSAY ON SUBALTERNIZED ALTERITIES IN THE PHYSICAL SCIENCES

Alan Alves-Brito[1]
https://orcid.org/0000-0001-5579-2138

Kaleb Ribeiro Alho[1]
https://orcid.org/0000-0003-0694-665X

ABSTRACT:

One of the great challenges of anti-racist education in Brazil is to design and implement it in areas that are outside of the ethnic-racial discussion. This essay offers critical reflections on how education for ethnic-racial relations can help to problematize the notions of development and progress (linked to the modern scientific episteme) in science classrooms through the analysis of cases of political-territorial conflicts that involve traditional communities and State-owned enterprises. We discuss striking cases of ethnic-racial conflicts in Brazil and the United States relating to the installation of observatories, a hydroelectric power plant, and a rocket launching base, interpreted as elements of development in the context of the Modern and Contemporary Science Project, but which, alternatively, revive the tensions between Tradition and Scientific Reason. We argue from a historical, philosophical, and epistemological point of view, seeking to substantiate and encourage the discussion and implementation of Laws 10.639, 11.645 and the National Curriculum Guidelines for Quilombola School Education in basic and higher education science.

Keywords:
Teaching and Dissemination of Astronomy and Physics;
ERER;
Quilombola School Education;
Laws 10.639/11.645 and Racism.

EDUCAÇÃO PARA AS RELAÇÕES ÉTNICO-RACIAIS: UM ENSAIO SOBRE ALTERIDADES SUBALTERNIZADAS NAS CIÊNCIAS FÍSICAS

RESUMO:

Um dos grandes desafios da educação antirracista no Brasil é ser pensada e executada em áreas que se colocam à margem da discussão étnico-racial. O presente ensaio traz reflexões sobre como a educação para as relações étnico-raciais pode ajudar a problematizar as noções de desenvolvimento e progresso (muito íntimas da episteme científica moderna), em aulas de ciências, a partir da análise de casos de conflitos político-territoriais que envolvem comunidades tradicionais e empreendimentos de Estado. Discutimos casos marcantes de conflitos étnico-raciais no Brasil e nos Estados Unidos no que tange à instalação de observatórios, de uma usina hidrelétrica e uma base de lançamento de foguetes, interpretados como elementos de desenvolvimento no contexto do Projeto Moderno e Contemporâneo de Ciência, mas que, alternativamente, resgatam as tensões entre a Tradição e a Razão Científica. Argumentamos do ponto de vista histórico, filosófico e epistemológico, buscando justificar e fomentar a discussão e a execução das Leis 10.639, 11.645 e das Diretrizes Curriculares Nacionais para a Educação Escolar Quilombola na educação em ciências, nos ensinos básico e superior.

Palavras-chave:
Ensino e Divulgação de Astronomia e de Física;
ERER;
Educação Escolar Quilombola;
Leis 10.639/11.645 e Racismo.

1 Universidade Federal do Rio Grande do Sul, Instituto de Física, Porto Alegre, RS, Brasil.

EDUCACIÓN PARA LAS RELACIONES ÉTNICO-RACIALES: UN ENSAYO SOBRE ALTERIDADES SUBALTERNIZADAS EN LAS CIENCIAS FÍSICAS

RESUMEN:

Uno de los grandes desafíos de la educación antirracista en Brasil es ser diseñada e implementada en áreas que están al margen de la discusión étnico-racial. Este ensayo aporta reflexiones sobre cómo la educación para las relaciones étnico-raciales puede ayudar a problematizar las nociones de desarrollo y progreso (muy vinculadas a la episteme científica moderna) en las clases de ciencias a partir del análisis de casos de conflictos político-territoriales que involucran a comunidades tradicionales y empresas estatales. Discutimos casos impactantes de conflictos étnico-raciales en Brasil y Estados Unidos con relación a la instalación de observatorios, una central hidroeléctrica y una base de lanzamiento de cohetes, interpretados como elementos de desarrollo en el contexto del Proyecto Moderno y Contemporáneo de Ciencia, pero que, alternativamente, rescatan las tensiones entre Tradición y Razón Científica. Argumentamos desde un punto de vista histórico, filosófico y epistemológico, buscando justificar y fomentar la discusión e implementación de las Leyes 10.639, 11.645 y los Lineamientos Curriculares Nacionales para la Educación Escolar Quilombola en la educación en ciencias, en la enseñanza básica y superior.

Palabras clave:
Enseñanza y Difusión de Astronomía y Física;
ERER;
Educación Escolar Quilombola;
Leyes 10.639/11.645 y Racismo

EDUCATION AND OUTREACH OF PHYSICS AND ASTRONOMY IN AN ETHNIC-RACIAL PERSPECTIVE

Black, quilombola and indigenous people in Brazil have their alterities subalternized in the (physical) sciences, making them the most favored targets of racist policies, historically drawn away from schools, universities, and sites of cultural and scientific empowerment. The education and outreach of de-colonial and anti-racist science is, therefore, a powerful antidote against the poison of epistemic racism (Carneiro, 2005). The concept of epistemic racism used in the present article is the one adopted by the Black philosopher and activist Sueli Carneiro, who articulates and broadens it to encompass the persistent production of cultural indigence of Black (and indigenous) thinking. Epistemic racism denies access and permanence to education to Black and indigenous people, downplaying their intellectual works and ultimately impacting their self-esteem. Devaluing Black and indigenous people means devaluing their ways of being, doing, and thinking. Therefore, to Sueli Carneiro, the process of devaluing spotted in epistemic racism is individual (subjective) and collective (systemic). In the context of epistemic racism, Black and indigenous bodies are incapable of producing their own knowledge or even accessing the one legitimized by hegemonic systems. On its turn, the concept of subalternization employed here is based on the ideas of Spivak (2010), in which subalternized people are understood as invisible, voiceless, and lacking possibilities of social change. *Racist policies*, on their turn, are understood as a facet of necropolitics—a concept discussed by Mbembe (2017).

In this sense, one of the great challenges in scientific education and outreach in Brazil—particularly in the field of physical sciences (astronomy and physics) is to strengthen the article 26A of the Brazilian Educational Law of 1996 (Brazil, 1996). This important legal milestone determines the obligatoriness, at all levels of national education, of the study of African and African-Brazilian (Law 10.639; Brazil, 2003) and Indigenous (Law 11.645; Brazil, 2008) History and Culture. In the case of quilombola people, the Brazilian Educational Law for Quilombola School Education (DCNEEQ; Brazil, 2012) plays a singular and *differentiated* role in the discussion about anti-racist education (Alves-Brito; Bootz; Massoni, 2018; Alves-Brito, 2021a).

Unfortunately, as is well contextualized in recent literature (Alves-Brito; Bootz; Massoni, 2018; Pinheiro; Rosa, 2020; Alves-Brito, 2021b; Oliveira; Alves-Brito; Massoni, 2021), the fields of physics and astronomy lag behind in debates on racism and ethnic-racial relations in devising anti(racist) practices and enforcing the main legal marks that guide antiracist education in Brazil that should be put into practice in all the fields of knowledge. Technically, we cannot downplay the core role of astronomy in the National Curriculum Common Core for Basic Education (NCCCBE; MEC, 2018). Astronomy is the main link between the topics in physics and geography in primary school, urging us to develop strategies in education and communication in these areas with the main aim of dismantling racism in all its occurrences, particularly institutional and epistemic, which strongly impact policies used in institutions of scientific education and outreach in Brazil. In addition, the discussion of reflections on the nature of science in courses on the teaching of physics and the articulation between physics and astronomy in the same courses is but inceptive and fragmented (Ferreira; Custódio, 2021; Slovinscki; Alves-Brito; Massoni, 2021).

This essay draws upon such concepts as development, progress, State, modernity, coloniality and indigenous sciences, which are found in theoretical studies. For our discussion here, the notion of Modernity, arising from the European invasion of the so-called New World (Munanga, 2019), is of particular interest, in which reason is seen as something intrinsic to the European colonizing bodies. Likewise, the idea of Nation-State in modern times is important, mainly from Portuguese colonization, that is, Colonial, Imperial, and Republican Brazil, encompassing slavery, abolition, and post-abolition (Schwarz and Starling, 2015). Coloniality, on its turn, in the sense proposed by Quijano (2010), understood as a constitutive and specific element of the world standard of capitalist power, but also in the perspective of indigenous and quilombola communities which do not posit that colonialism is over (Santos, 2015; Krenak, 2019; Serejo Lopes, 2020). Coloniality not only persists as is supported by ethnic and racial classification of the populations of the Earth as a tool for control and power. It originates and spreads around the world, according to Quijano, from America, with colonialism. For this author, the main idea of Eurocentric coloniality/modernity is materialized in "a conception of humanity according to which the world population is divided into inferiors and superiors, irrational and rational, primitive and civilized, traditional and modern" (Quijano, 2010, p. 86).

Our reflections on the notions of development and progress draw upon the ideas of Saar (2019), according to whom development is an undiscussable norm of progress in human societies, inscribing the advancement of these societies within an evolutionist perspective, negating the diversity of narratives and the modalities of responses to the challenges presented by it. In addition, to Saar, development (and its implicit notion of progress) "rationalized the world even before having the means of transforming it" (Saar, 2019, p. 21). Progress and reason are words of order in the epistemic context of modern times in the West. This notion of progress is resisted and battled by Black and indigenous communities, oppressed by the power relations imposed in the States that consistently enforce policies of death.

Finally, indigenous sciences are seen here as the pool of ancestral knowledge and practices that articulate self-determination of indigenous peoples in search for social and cognitive justice, including historical, linguistic, cultural, psychological, social, and economic issues. The indigenous sciences are their cosmogonies, their ways of being and living which are de-colonizing, since, for indigenous persons, the end of the world came about with the European invasions projecting a modernity based on cosmophobic development (Santos, 2015; Kopenawa e Bruce, 2015; Krenak, 2019; Serejo Lopes, 2020).

Within this context, this article presents a critical reflection about the importance of education and outreach of astronomy and physics in Ethnic-Racial Education (ERE). For such, four paradigmatic ethnic-racial conflicts in the history of the physical sciences (astronomy and physics) are addressed, two of them taking place in Brazil (Alcantara and Belo Monte), and two in the United States of America (Mauna Kea and Arizona), revealing complex relationships between Tradition and Modern Reason. These conflicts put contemporary physics and astronomy in one of the greatest world crises related to how the relationships

between scientists and society have been marked by the ethos of global systems such as colonialism, capitalism/neoliberalism, and patriarchy, in an unequal relationship of power, in which racism is its main material and symbolic expression. From these political-territorial conflicts, the notions of development and progress, which are remarkably close to modern scientific epistemology, may be problematized in science classes.

In order to conceptually circumscribe the "ethos" of global systems and its associated concepts, mainly in the perspective of epistemology, we highlight the ways in which the Peruvian thinker Aníbal Quijano identifies the coloniality of power with capitalism and its consolidation in Europe in the 15th and 17th centuries. For him (Quijano, 1997), the coloniality of power leads the Planet Earth to produce knowledge that is classificatory, in which eurocentrism becomes the metaphor for describing the coloniality of power, which does not exist without the idea of subalternization. Local European knowledge is seen as global. Ethnicity and Racism become part of the discursive field. Ethnicity, from the ethnic categories created in the new system-world (white, Black, indigenous, among others) and racism as part of the strategy of colonial domination to organize the exploration of the modern system-world. The researcher Marimba Ani also helps us to understand Eurocentrism from its economic expansion and the subjugation of the "other" (Black, indigenous, non-European), in which conquest, exploitation and appropriation materialize global systems (ANI, 1994). There is no Eurocentrism (modernity) without racism, therefore.

ETHNIC-RACIAL CONFLICTS: BUILDING NEW ALTERITIES IN THE PHYSICAL SCIENCES

The ethnic-racial conflicts are diverse/differentiated among individuals, groups, or societies with distinct ethnic, racial, social-cultural, religious, political, and territorial features. For Candau (2001), the issue of ethnic-racial conflicts is related to the tension between equality and difference and, thus, is a very contemporary one. For the author, the problem is not in affirming a pole and denying the other, but actually arriving at a dialectic view of the relationship between equality and difference. In the context of this essay, the conflicts are analyzed from the polarity *Tradition* vs *Modern Science*. [1]

For the discussions focused on in this essay, 21st century physics and astronomy are the very ethos of Modernity. Referred to by the History of Science, they are in articulation with other basic sciences in order to answer, in collaboration with Cosmology, some of the most fundamental scientific questions: How did the Universe form and evolve? In addition, since the 17th century, physics and astronomy are part of the groundwork of the concept and understanding of science, technology, development, and innovation (Pires, 2008; Lightman, 2016; Alves-Brito, 2021a). Physics has been responsible for great revolutions in technologies and information for centuries, from the discovery of electricity to the effects of the Fourth Industrial Revolution (Alves-Brito, 2021a). The studies in physics have been pouring over very impactful projects, engaged in the construction of sensitive instruments that operate from atomic to astronomic scales. Astronomy, on its turn, has been creating new frontiers of knowledge, mainly through physics and astrobiology. In addition, there is no thinking about astronomy in this century without previously reflecting upon the impact on science in general of the creation of ever more powerful telescopes and ever more sensitive instruments, able to operate in different electromagnetic ranges. In this process, there is a high demand for the development of software and hardware capable of processing and storing a growing number of data, producing, each night of observation, that which makes Astronomy one of the most complex sciences in contemporariness (Alves-Brito; Cortesi, 2020), taking into consideration not only intrinsically scientific questions, but mainly outward demands (Lightman, 2016).

Tradition, on the other hand, is interpreted here from the ideas of Bimwenyi-Kweshi (1981), being possibly constructed from a logic that counters Modern Reason. It can contain the configuration of spiritual values, which, on their turn, give meaning to life. This spirituality is conspicuous in the way of life in Black African, African-Diasporic, and Indigenous communities. Culture (Muniz, 2005) has, therefore, a markedly

sociopolitical dynamics in tradition. Physics and Astronomy, as modern sciences, counter Tradition, since, in principle, they are not based on values and epistemologies arising from tradition. The Tradition-Modernity dichotomy implies the latent idea that the former stands for untruth, being scientifically irrelevant, and thus with no right to a voice, since it is not expressed through theoretical, experimental and/or observational objectivity materialized in the scientific method.[2] It is in this point that the conflictive relationship between Tradition and Modernity lies. Both offer explanations for the world and reality that should not be cosmophobic (Santos, 2015). ERE and anti-racist education in science have, it seems to us, the crucial role of recasting and re-signifying them in the sense of searching for principles of life and inclusion, via the mediation of ethnic-racial conflicts in its many intersections (race, gender, class, geographic origin, generation, among others).

What follows is a list of the main ethnic-racial conflicts in Brazil and the United States of America, upon which we aim to reflect in this essay, involving Tradition (knowledge and practices, that is, ancestral sciences proposed by Black, quilombola and indigenous people) and Modernity (installation of hydroelectric plants, launching platforms for satellites and astronomic telescopes/observatories). Then, critical reflections on each of them are provided within the context of antiracist education and the promotion of physical sciences to strengthen subalternized alterities.

a) Alcantara Space Center and Quilombola Territory

Alcantara is a small Brazilian municipality of around 22,000 inhabitants, relatively close to São Luís, capital city of the State of Maranhão. It houses hundreds of quilombola communities forming the Alcantara Quilombola Territory (AQT), the Santa Tereza Territory (STT) and the Cajual Island Territory (CIT). It is, therefore, one of the most significant municipalities in terms of the African and African-Brazilian Traditions in Brazil. Since 1983, the AQT and the Alcantara Space Center (ASC) have been involved in one of the most difficult ethnic-racial conflicts between traditional communities and physical and space sciences in Brazil, founded on the development project of Modern and Contemporary Science (Serejo Lopes, 2020).

Beyond the visible agenda of science and technology, there are economic and military interests involved in this conflict. Recently, the Revista Fapesp (2021, n. 307),[3] one of the most prestigious scientific journals in the country, reported that two public calls for non-military use of the ASC were in effect, and the first had selected four specialized companies which would draw upon the resources of the center. The companies selected were the Canadian C6 Launch and the North American Virgin Orbit, Orion AST, and Hyperion Rocket Systems.

The Alcantara Space Center is located next to the Earth's Equator, which makes it economically very advantageous for the Brazilian State due to the launching of Brazilian satellites in the orbit and the elaboration of bilateral agreements with countries in the Global North.[4] From the QTA's viewpoint, it was an inappropriate invasion of its territory and degradation of its cultural practices and values as is typical of Brazilian racism that for centuries has been subjugating Black communities, mainly the quilombola (Nascimento, 2008).

In a 2004 article, only one year after the approval of the Law 10,639/2003 and eight years before the approval of the DCNEEQ/2012, the Revista Fapesp (2004, n. 96)[5] highlighted that

> *The municipality of Alcantara, in the State of Maranhão, have a technological (housing a Space Center) and touristic (preserving its colonial architecture) vocation, although most of its inhabitants live in African conditions of poverty: 73% of the population of 21,000 live in the rural area, the monthly income of 59% of families being under R$ 100.00. A partnership between the Brazilian Space Agency and the Brazilian Agricultural Research Corporation (Embrapa) will attempt to improve the human development indexes of the region. The idea is teaching the small entrepreneurs strategies to increase their productivity. They currently use 300-year-old techniques based on the hoe and the matchet, being unable to cultivate territories of more than one acre and, therefore, of creating wealth. They plant manioc, beans, corn, and rice. When the soil becomes wasted, they abandon it, deforest nearby areas and return there a long time after (Revista Fapesp, 2004, n. 96).*

In the same article, it is read that, according to Zeke Beze, consultant of the United Nations Development Program at the time, "the obstacle, in Alcantara, is technological."

The same journal published an article in 2019, that is, seven years after the promulgation of the DCNEEQ, in which the Minister of Science and Technology at the time, Sérgio Rezende, one of the (inter)nationally most respected and best-known physicists, criticized the *intransigence* of the social movements associated to the quilombos, which, according to the article, refused to discuss the sharing of territories that belonged to the remaining community.[6] These facts clearly materialize the ethnic-racial conflicts (Tradition vs Modernity). Once more we call upon the readers to focus on the asymmetric power relationships between the Union and the AQT within the context of Coloniality, Capitalism, and Patriarchy, which have, in racism, its most expressive social technology (Mignolo, 2000; Quijano, 2010; Santos, 2015; Maldonado-Torres, 2018). We understand power relationships here the ways in which the Imperial Systems (Colonialism, Capitalism, and Patriarchy) have articulated the concept of humanity in order to classify people. In this sense, modern and contemporary science, acting alongside the imperial powers, fostered unequal power relationships between these and the traditional communities. Serejo Lopes (2020) deeply presents the main questions involved in the quilombola territorialization in Brazil. The process of acknowledgment of quilombola territories is an interesting example of how these power relations operate. Even if quilombola communities exist in Brazil since the 16th century, in June 2022, only 144 titled[7] communities are still in existence (of the more than 6,000 existing ones).

b) Belo Monte - Xingu River

One of the most prominent cases of ethnic-racial conflicts involving the physical sciences and geography is located in Pará, Northern Brazil, in the region known as Altamira and the basin of the river Xingu—one of the biologically richest environments of the Amazônia.[8] The issue of the hydroelectric company of the Xingu river, which began to be built in 2010, became famous worldwide in late years due to the building of the Belo Monte hydroelectric company (then known as Usina Kararaô).

As historicized in Fleury and Almeida (2013), the building project of the Belo Monte Dam started in 1975, from the Studies of the Hydroelectric Inventory of the Hydrographic Basin of the Xingu River. This would become the largest national project of the end of the 20th century and beginning of the 21st century. The ethnic-racial conflicts that ensued pervaded a series of interpretations of the idea of local and national development or, alternatively, of how destructive that project could become. The idea of development was implied in the notion that the Hydroelectric Dam of Belo Monte was aimed to be one of the largest in the world, generating more than 1,100 MW/hour. On one side of the conflict, stood the Norte Energia and the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), both in defense of a national project of development; on the other side, the indigenous peoples of Xingu, living in perfect harmony with Nature, standing as the voices of the Forest and against the death of fish, the water and the woods, against the disarticulation of communitarian life and its means of life and subsistence (Kopenawa e Bruce, 2015; Krenak, 2019). The building of the Belo Monte Dam crossed distinct phases of national politics and, despite the conflicts still in existence, was always a governmental priority in the eyes of the great contractor companies fueled by capitalist interests, who see themselves as above the interests of the local population.

Once more we can conclude that there are contrasting interpretations of the concept of development and that the narrative struggle in the ethnic-racial conflicts involving territorial politics is based on the disarticulation of ancestral (spiritual) values of the indigenous peoples and the peoples of the Earth and the Forest instead of a developmental agenda self-proclaimed Universal, articulated to the Capital.

c) Mauna Kea Observatories - The Kānaka Maoli People

The Mauna Kea, an extinguished volcano in Hawaii has been historically one of the most celebrated places for astronomic observation in the United States of America, for centuries leading many of the most robust

projects in world astrophysics. In Mauna Kea, the Keck Telescope (10m-diameter) is located, one of the most powerful nowadays on earth. Since the 20th century, the indigenous peoples living in the Island of Hawaii have been negotiating the transactions around the installation of many astrophysical development projects.

However, in later years, the Mauna Kea has staged one of the most controversial ethnic-racial conflicts. On one side, astrophysicists, engineers, and governments wanting to install at the Mauna Kea Observatories (more precisely on the summit of the Mauna Kea Volcano), the Thirty Meter Telescope (TMT); on the other side, the Kānaka Maoli, the native population of the region.

Within the intricate power relationships of the Modernity project discussed here, the TMT, a 30-meter telescope, belonging to the new class of extremely large telescopes, will cause a revolution in Astronomy for the next decades, since, alongside other similarly sized telescopes (25-45 meters), the TMT will allow deeper and more sensitive access to celestial objects. With this new class of telescopes, Astro(physics) is expected to solve some of the enigmas that have sought for answers throughout the last centuries: the origin of the first galaxies, the large-scale description of the structure of the Universe, the composition of the intergalactic environment, the physics of the fist instants of the Universe, the nature of the dark matter, the definition, and the role of dark holes, among other mysteries. The building of telescopes, observatories and the installation of many instruments stand for the development of Modern and Contemporary Astrophysics. It is worth highlighting that, even if hosted and coordinated by the USA, the TMT project involves other heavy-weight partners in the international scenery such as, for instance, the governments of Japan, China, India, and Canada.

For the Kānaka Maoli Tradition, the Mauna Kea is its very body-territory, where its memories and alterities are located (Salazar, 2014). Its existence makes sense only from the Mauna Kea found in the narratives about the origin of the world and the people. In its cosmology, the Mauna Kea binds heaven and earth and originates the water, the fundamental element for the rituals and the lives of the Kānaka Maoli (Salazar, 2014). In the tradition, there is, therefore, a conception of the sacred that conflicts with the modern project of science, and this is the main source of the conflict occurring in Mauna Kea.

d) Mount Graham International Observatory - Apache San Carlos Indigenous Community

Another case of ethnic-racial conflict in the physical sciences that should be highlighted involved the installation of the observational site of the *Mount Graham International Observatory* (MGIO), near the peak of Mount Graham, Pinaleño Mountains, southeastern Arizona, USA. The MGIO is associated to the Department of Astronomy of the University of Arizona, which, operated by the *Steward Observatory*, is composed of three main units: (i) *Vatican Advanced Technology Telescope* (VATT), mirror of 1.8m-opening; (ii) *Heinrich Hertz Submillimeter Telescope*, which operates in the frequency of the radio with a disk-shaped antenna of 10m-opening; and the (iii) *Large Binocular Telescope* (LBT), composed of two mirrors of 8.4m-opening each.

In the viewpoint of modern development, the *Steward Observatory* soon noticed the astrophysical potential that the 3,268-meter-high peak had to the installation of several telescopes. In addition, *Mount Graham* presents extraordinary conditions for observation: excellent seeing,[9] scarce light pollution and a predominance of limpid nights. In addition, it is strategically located at 240km of the city of Tucson.

Of native origin, Pinaleño means "deer." The Pinaleño Mountains are part of the *Coronado National Forest*. As in other cases reported here, the native groups in Arizona stood up for their traditions and their cosmological relationships with the mountain and its environment, which were being threatened by the process of astronomic installation then occurring (Bezerra, 2020). The ethnic-racial-environmental conflict of Mount Graham had its apex in the years 1980 (Bezerra, 2020).

Just as in other cases, the peak of Mount Graham is shrouded in cultural and spiritual meaning (Tradition) for the Apache San Carlos Indigenous Community, whose reservation is found on the bottom of the

MGIO. For generations, these original peoples have sown and reaped their medicinal herbs and have related based on another logic with the mountain.

In 2002, the first light took place at the *Large Binocular Telescope* (Bezerra, 2020), signaling once more the dominance of scientific (universal) interests over the social and cultural (local) interests of the native peoples of Arizona around the MGIO.

IMPLICATION FOR EDUCATION AND OUTREACH OF PHYSICAL SCIENCES

This section is divided into four axes. Its choice was based on our understanding that the ERE and the differentiated projects in education—such as indigenous and quilombola schooling (Munduruku, 2012; Gomes, 2017)—take to the classroom and other places of scientific outreach the need to imagine and build alterities that are Black, indigenous, and quilombola beyond the processes of subalternization imposed by the colonial system of power. For such, drawing upon the ethnic-racial, political, and territorial conflicts previously addressed, this section argues that the education and outreach of (physical) sciences should reassess the concept of development implied in the idea of science and technology (Axis 1). In addition, they must take into consideration the fact that the ERE and the differentiated projects in education carry within themselves a discussion that is political, linked to bodies-territories thoughts that do not excise their ancestral sciences from their ways of being and living (Axis 2). This unique perspective of articulation between science and politics must reach the classroom. We argue that critical race theory (CRT) is a fundamental theoretical, political, legal, and epistemological reference that, acting alongside the fundamental principles of Black and indigenous social movements, have important contributions for the mediation of ethnic-racial conflicts in schools and institutions that promote public policies in education (Axis 3). Finally (Axis 4), as reflection, we offer basic questions that may be articulated in the classroom and in non-formal educational spaces to strengthen the alterities represented here.

AXIS 1: ALTERITIES AND THE CONCEPT OF DE-VELOPMENT

At the roots of the ethnic-racial conflicts addressed here—which embody political-territorial conflicts—the modern construction of the concept of race stands out. The idea of race is directly linked with the meaning and concept of alterity (Black, quilombola, indigenous) from the process of colonization. De-colonial studies place alterity and the idea of race at the center of the debate (Quijano, 2005; Maldonado-Torres, 2018; Rosa; Alves-Brito; Pinheiro, 2020; Alves-Brito, 2021a;b). The development project of Modern Science operates the idea of "I" (European/colonizer) against the "other" (non-European/colonized/enslaved). In the history of Brazil, exterminational and integrational policies have destroyed indigenous peoples, spirituality (in the Christian tradition) justifying the Eurocentric ideology that these peoples, not possessing the written word, soulless, and lawless, should be civilized to enter the world of "development," anchored in the Portuguese colonial project (Munduruku, 2012).

There is, therefore, at the core of the conflicts addressed here an implicit question of deterritorialization of the "other." The colonized *other* has their (im)material and symbolic territory expropriated so that environmental racism (Rocha and Santana Filho, 2008) should be broadly discussed in education in sciences committed to the antiracist struggle.

Aimed primarily at scientific enquiry, either pure or applied, we see that the great astrophysical development projects are inserted within strategic places: next to the Equator of the Earth, in the case of Alcantara, or in distant sites, usually in arid regions of high altitudes as deserts or mountain peaks, in the case of Mauna Kea and Arizona. These regions are sought to minimize problems caused by the gases of the earthly atmosphere in astronomic observations, since part of the electromagnetic radiation (ultraviolet and infrared)

is retained by the Earth's atmosphere. The robust projects of the physical sciences aim to escape from great urban centers. There is no way of building a great hydroelectric company if not near water basins, which are in isolated, rural places, removed from urban centers.

In the Southern hemisphere, with its desert (Atacama) and its mountain ridge (Andes), Chile is the country with the greatest number of observatories and instruments of astronomic observation, many of them kept and financed mainly by European countries and the United States of America, world leaders in the field. It is worth highlighting that other countries in the region, such as Brazil, also establish projects of scientific collaboration with programs developed in Chilean soil. The choice for Chile, years ago, was not neutral or based solely on its natural potential. There were also political and economic issues related to this choice. The small country, exporter of wine and minerals, located between the Pacific Ocean and the Andes Ridges, has been for many years a neoliberal laboratory (new rationality) in the world. Even if the country has undergone a twist in its recent social structure (Collaço, 2021), these movements do not reach the astronomic facilities found there,[10] leading us into referring once more to the (neo)colonial relationships imposed by coloniality. Within the next years, an estimated 70% of the world astronomic potential will be in full development in Chile—a case of development coupled with the "rent of the sky." In this sense, in terms of ethnic-racial relations, we can ask ourselves where are the alterities of the original peoples of Chile (Mapuches, Aymaras, Colla, Quechua, Rapa Nui, Yagán, Pehuenches, Huichilles, Kawashkar and Alacalufes) within these "astronomic" developments, where are their cosmological narratives and semiotics in the schools and cultural spaces?

The logic of occupation of large or small areas for modern development projects in science and technology is based on the idea that there is no inhabitable life in these territories and, even if there is, they are not human, which justifies the physical and psychic violence in these territories lurking behind the neo(colonial) subordination, marking these alterities as synonymous with backwardness. Once the sites are selected, as we see in the cases above, the communities are not invited to participate in the process of discussion of the benefits and the ills of the projects, masked by the banner of development. Nor are these communities asked about their interest in such projects. No safeguard plans are developed with the participation of the local population, not even in projecting how the changes may be organized and executed with less impacts on existence (of the living and the non-living) which constitute their communities.

As summarized by López (2018), the strategies of domination of the collective social imagination involve a rhetoric of subalternization historically referred by the construction of hierarchic relations of power that conflict Tradition and Modernity:

> *It is commonly found in many contexts of colonial relations and implies conceiving of oneself as forerunners of civilization and development, whose mission is to guide other human being into "modernity," "reason" and "maturity." In addition, they view the local populations as "uncivilized savages." Their social worldview is implicitly or explicitly that of 19th century unilinear evolutionism, which deems local populations as anterior stages of human development. Thus, they are associated to other groups as "necessity of tutelage," as children and women. The behaviors of all these groups are classed as "irrational," "mystic" and "emotional" (López, 2018, p. 444).*

In recent times, the Project of education and scientific promotion aligned with the Hegemonic Modernity articulates *development* from the 17 Objectives for Sustainable Development (OSD), the ground of the world agenda within the ambit of the United Nations Organization (UNO; Figure 1; see discussion in Alves-Britto, 2021a). This agenda has been the basis of the global commitments for development and the design of ways of being and relating in societies and scientific organizations worldwide. In this sense, the physical and space sciences play a fundamental role in the implementation of what is foreseen in the Agenda UNO 2030, mainly within the Fourth Industrial Revolution (FIR), which is excludingly in course.

Once more, we need to think about what development means in physics and astronomy and how we can build projects of education (in sciences) that are differentiated, directed to Black, quilombola, and

indigenous territories within the context of the FIR (Alves-Brito, 2021a). The ethnic-racial conflicts discussed here are actually related to the notion of development operationalized in different projects, particularly those whose banner are the ODS of the Agenda UNO 2030.

Figura 1. Objectives of Sustainable Development (OSD), UNO 2030 Agenda

As one of the premises of antiracist education is the decolonization of thought, the ideas of the quilombola thinker Antônio Nêgo Bispo dos Santos (Santos, 2015) are crucial to help us reflecting about the ethnic-racial conflicts addressed here. This author presents an authentic perspective of development of the ERE in Brazil. For him, the Modern and Contemporary project of science, with its colonial pedagogy in dealing with original and traditional communities, particularly the quilombola communities, is focused on a discourse of exterminating the "other," the one who is different from the "I" (white/European/colonizer). Such a project is grounded in extermination and de-velopment practices. In this sense, the relationship between science and the people is based on the break of affective bonds and involvement (thus, de-velopment) of different natures—material, symbolic, aesthetic, and affective. Here we interpret this de-velopment as actually a strategy of, within the ethnic-racial relationships, reaffirming the ongoing process of dehumanization of Black bodies and original peoples (racism), excluding them from power discussions and decision-making spaces and the autonomous and powerful knowledge production.

There is, then, in the historical processes of education in the sciences, a breaking of bonds, an affirmation of de-velopment proposed by Nêgo Bispo. And these logics of de-velopment (environmental racism) will mark and justify, in articulation with scientific racism (Rosa; Aves-Brito; Pinheiro, 2020; Alves-Brito, 2021b), much of the ethnic-racial conflicts presented in this article.

AXIS 2: ALTERITIES AND COSMOPOLITICS

The traditional communities in Alcantara, Xingu, Mauna Kea, and Arizona, as many others around the world, evidently regard the areas in which they live and cohabit as territories, not merely as *land*; these territories are part of their bodies, powerful spaces strongly linked to their relationship with the non-human world, mainly the non-visible beings. For them, these territories are fundamental parts of their cosmological conceptions, emotions, sensations, and social-anthropologic bonds (Kopenawa e Bruce, 2015; Santos, 2015; Krenak, 2019; Serejo Lopes, 2020).

From the cosmological viewpoint (Stengers, 2014; Alves-Brito, 2021b;c), there is a sense of collectiveness that pervades these different experiences, which, in the educational context, strengthens the understanding that race, by definition, only makes sense in its relationship with the other. There is, in Stengers's cosmopolitics, a sense of sharing the world of the people excluded from Modernity. And, therefore, in this racial literacy, in Brazil or in the United States, being Black/indigenous/quilombola has its peculiarities. The cosmopolitical perception reaffirms the concept of race as dynamic and bound in space and time. However, it universalizes the experience of racism, as structure, uniting the histories of Brazil and the USA to other Black, quilombola, and indigenous histories worldwide. The concept of race is understood as political, and cosmopolitics as the politics of Modernity in crisis (Stengers, 2014).

Cosmopolitics pervades culture and, in this sense, Muniz Sodré, one of the foremost Black intellectuals, teaches us that Black culture (the same is valid for the cultures of indigenous peoples worldwide) is not based on the idea of linearity of exchanges. They were always symbolic (Sodré, 2005). This is exactly why racialized cosmologies (Alves-Brito, 2021b;c), outside the *western* context, neither operate nor communicate from a cosmophobic reference point. The racialized cosmologies include not only human beings (alive and dead), but also animals, plants, and minerals. As long as this feature is treated from the values of modern science as animism, it can be (and is) the very logic of organization of other cultures (Sodré, 2005) and, therefore, scientists/engineers/politicians need to be prepared to foster and respect diverse alterities in the physical sciences or in racialized cosmological relations. This is an educational process, not a biological datum.

As discussed in Alves-Brito (2021a), values, beliefs, and attitudes arising from African, African-Brazilian, and indigenous matrices are built by other marks that are not always understandable (and even less tangible) for the constructs of modern science, this being the main point of the discussion around ethnic--racial relations in physical sciences, which ignore the ancestral sciences based on other references of reason (emotions, for instance). This is actually the basilary question when we think about the ethical sense of education in sciences for ethnic-racial *relationships*, which can be successful only insofar as they happen within *relationships* (modern science in a dialog with ancestral sciences). Without that, it will be impossible to mediate the ethnic-racial conflicts in scientific practices, be it in whatever context they are.

As discussed throughout the text, the communities involved in ethnic-racial conflicts in Brazil and the USA tackled here are those that are historically dehumanized by the Modern and Contemporary Project of Science. Aníbal Quijano, one of the great Latin intellectuals, reminds us that the idea of race/ethnicity (Black, quilombola, indigenous) is laced with the standard idea of power in a mental construction offered by the experience of colonial domination, structured by Eurocentrism (Quijano, 2010). There is no way of moving if we do not radically restructure our curricula and our practices in all the areas of Brazilian education.

However, the Curricular Refences articulate (yet) silencing, erasure, and extermination of ethnic-racial conflicts and the voices of original peoples and those of African and African-Brazilian matrices within the context of Teaching in Sciences in basic education and the Institutions of Higher Learning. In general, when these ways of existing appear in these narratives, they are represented in a passive and apathetic light. But it is symptomatic, through the conflicts highlighted here, to perceive that these communities keep on resisting and, therefore, they are not motionless in time nor are passive or indifferent to the crossings of presence in their lives.

In this sense, it is urgent that the knowledge and practices (ancestral sciences) of different peoples here discussed be encompassed in schools, universities, and spaces of scientific promotion, but not in a folklorized context, static in time. The recuperation of the historical struggles of these peoples contribute to frame other identities and alterities, more autonomous and empowered within the context of physical sciences, whose very books often fail to depict the ethnic-racial diversity of the country (Rosa e da Silva, 2015).

AXIS 3: ALTERITIES AND CRITICAL RACE THEORY

We argue, moreover, that Critical Race Theory (CRT; Bell, 1992; Delgado and Stefancic, 2021) has a key role in education in sciences, in Brazil and the USA, to help us build Black, indigenous and quilombola alterities that are resilient, empowered and politically aware of their historic struggle. The methodological and epistemological pathways embraced by CRT, updated in the views of Milner and Howard (2013) and Delgado and Stefancic (2021) are expressed in five tenets: (i) intercentricity of race and racism (and their intersectionalities); (ii) challenging the dominant ideology (in relation to the dismantling of the ideas of neutrality, objectivity and meritocracy); (iii) commitment to social justice (breaking all the racialized privileges, mainly the academic-scientific access); (iv) interdisciplinary perspective (dialogs between areas of knowledge, competences and practices); and (v) centrality of experiential knowledge (the *escrevivência* – narratives of life) which, in our opinion, may be partially illustrated by the concept of *escrevivência* of the writer and thinker Conceição Evaristo:

> *an act of writing of Black women, as an action that seeks to blur, unmake an image of the past, in which the body-voice of enslaved Black women had their potency of emission also under the control of slavers, men, women, and even children (Evaristo, 2020, p. 30).*

The CRT, linked to the ERE, is proposed here as an interesting key for thought to help us problematize, interpret, and even solve each of the ethnic-racial conflicts revisited in Brazil and the USA. The difference of CRT is that it is not only theoretical, but actually articulated by social transformation. Not only thinking and discussing, but also acting is needed to transform. The QTA exists for decades. In Mauna Kea, Xingu, and Arizona, the same dynamics of struggle and resistance can be seen. This is the groundwork of CRT: the struggle for social transformation in collectivity. And this is the other fundamental aspect that deserves to be highlighted from the cases here discussed: the potency of social movements to participate in the public debate of education and promotion of sciences (Munduruku, 2012; Gomes, 2017).

Ethnic-racial conflicts as these in Brazil and the USA, reported and interpreted in this text, are frequently led by the *elderly* (the masters of knowledge) of the communities involved, mainly women. There are, therefore, in these movements, theoretical, methodological, and epistemological constructs that pervade the being (experiencing) in the world anchored in ancestry and orality in a perspective of femininity. The social movements offer, thus, in their transformative dynamics, other ways of dealing with the other, incorporating other epistemologies which are not treated in the formal circuits of education and promotion of sciences, mainly in physical sciences.

Nilma Lino Gomes, Daniel Munduruku and Daniel Serejo Lopes, educators, researchers, and intellectual activists, have broadly discussed these gains for the case of historical, didactic-pedagogical, and onto-epistemological processes involving Black (Gomes, 2017), quilombola (Serejo Lopes, 2020) and indigenous (Munduruku, 2012) questions explaining the movements of resistance and traditional potency in Alcantara, Xingu, Mauna Kea, and Arizona.

In addition, teachers, educators, and politicians, articulators of Quilombola/Indigenous School Education with differentiated projects of education and even of public school regarded today as a Black territory from the viewpoint of the physical presence of Black students (Alves-Brito, 2021a), need to feel as part of the construction of these agendas of development in another logic of sustainability. It is necessary to strengthen and reaffirm the identity of the Black/quilombola/indigenous political being that needs to be in the world without being exterminated by the *ethos* of the Modern and Contemporary Project of Science.

The ethnic-racial conflicts discussed in the text offer, thus, challenges and opportunities to denaturalize questions that are part of the social, economic, and political decisions that dehumanize the Black, quilombola, and indigenous bodies-territories. The political question is, therefore, given. We know that, unlike other contents of the physical sciences, the historical questions and of nature in science are a challenge for teachers of science in all the levels. Not only that: Philosophers, epistemologists, and sociologists of scien-

ces addressed in the different didactic-pedagogical and cultural interventions have excessively euro-centered biases (Ferreira, Custódio, 2021), which again affirms epistemic racism (Carneiro, 2005) and the subalternization of alterities outside the "white-western" context. The CRT offers capillarity for the critical, scientific, and political debate that is sociologically transformative.

Moreover, the CRT offers a contribution to understanding the ways in which the juridical culture in Brazil and the USA deepens ethnic-racial inequalities and conflicts, be it in the specific question of the territories, be it in the application of educational policies such as the Laws 10,639/2003, 11,645/2008 and/or legal marks that orient indigenous and quilombola schooling. Tribunals, in general, maintain discriminatory systems against persons placed in subalternized groups (Moreira, 2020). In the context of the struggles discussed here, the CRT explains not only how the counter-narratives to the discourse of universalism of the rights are justified epistemologically, but also how the negation of the systemic nature of racism (Rosa; Alves-Brito; Pinheiro, 2020; Alves-Brito, 2021b;c) is materialized in the schools, universities, and other institutions that represent the State of Law. That is, in each of the political territorial conflicts discussed here, we cannot ignore the role of race in the process of juridical arguments (Moreira, 2020; Delgado and Stefancic, 2021). Even if our focus is the educational question, we cannot but stress that the origin of CRT in the juridical sciences has a significant contribution to reading the episodes cited here, since these struggles of land/territories involve primarily juridical aspects, which are often used as a justification to promote the epistemic and environmental racism "according to the law." The legislations are used and articulated, in the face of the public and institutional debate, within the ambit of the canonical idea of development, which obviously does not take into consideration the ancestral sciences and existences.

AXIS 4: NEW ALTERITIES ON SCHOOL, SCIENTIFIC MUSEUM, OBSERVATORY, AND PLANETARIUM

Finally, it is worth questioning, after all that has been discussed throughout this essay, where are the Black, quilombola, and indigenous thoughts *on the grounds of schools, scientific museums, observatories, and planetariums?* How could Black and indigenous students feel as part of the process of construction of the sciences if their knowledge and practices (ancestral sciences) are progressively denied in formal (and non-formal) processes of scientific education and culture? It is important to advance for the ethnic-racial conflicts addressed here to yield diverse opportunities of interpellations of themes and questions related to astronomy, physics, geography, technology, and development.

If well-articulated in the classroom, the conflicts addressed may, for instance, work as excellent laboratories of active methodology in argumentation and exercise of critical thinking without necessarily disregarding the contents of physics, astronomy, and/or geography.

Among the many questions that could direct the work in the classroom and spaces of scientific outreach, we highlight:

- Who are the peoples implied in the ethnic-racial conflicts in Alcantara, Xingu, Mauna Kea, and Arizona? What is the history of each of these peoples and how do they live today?
- What are their main cosmologies?
- How do they organize politically?
- What are the relationships of being, knowing, and power involved in ethnic-racial conflicts addressed?
- How do the questions involved can be articulated with the laws 10,639/2003 and 11,645/2008?
- How do the DCNEEQ and the Indigenous School Guidelines can help us understand and problematize the ethnic-racial conflicts discussed here?

- Why do the diverse groups (Tradition vs Modernity) involved in these conflicts have different views?
- What is Science, technology, development, and innovation for each of these groups?
- How do the scientific (or other) magazines and journals deal with ethnic-racial conflicts? Are they partial? Impartial? What factors justify your answer?
- Do you think there will be a solution for these conflicts?
- If you were given the power to solve these conflicts, how would you proceed?
- How do you think CRT can contribute to antiracist and democratic scientific education and outreach?

Beyond the questions above, the ethnic-racial conflicts in Alcantara, Xingu, Mauna Kea and Arizona allow us to deepen Felwine Saar's ideas about what *development* means, which is ultimately the essence of the Tradition-Modernity relationship that we tried to problematize:

> *Development is, then, an attempt to universalize an endeavor that had in the West its origin and its highest degree of realization. It is above all the expression of a thought that rationalized the world before having the means of transforming it. This evolutionist and rationalizing view of social dynamics was successful to the point of being adopted by almost the totality of the recently decolonized nations. Their deed was to stipulate western societies as reference and deprecate all other paths and ways of social organization. Thus, in a way of retroactive teleology, all the societies different from Euro-American societies became underdeveloped. The conversion of most nations to the passion for development in its western version was a successful work of denial of difference (Saar, 2021, p. 23).*

FINAL CONSIDERATIONS

We argue that the ethnic-racial experiences explored in Brazil and the USA pose fundamental questions about the history and nature of science in varied contexts of teaching-learning and valuing science as a political and cultural process, highly racialized, in which racism is a social technology deeply entrenched within the colonial, capitalist, and patriarchal logical organizations to ensure power (privileges). These are ethnic-racial conflicts oriented by a cosmopolitical interpretation in which the subject-nature-object relations are tensed with the modern notion of development.

The ERE and the differentiated projects of Quilombola and Indigenous Schooling in Brazil—historical triumphs of the Organized Social Movements—need to be put into practice at all levels of education. We can no longer comply with the idea that we live in a racially democratic country nor naturalize the fact that the school and scientific culture, potentialized in the experiences of the physical sciences linked to the UNO 2030 project, can be denied to Black and indigenous bodies. Intercultural dialogs must be built with an understanding of which are the civilizational marks involved in the communication between racialized cosmologies: on the one hand, Black, quilombola, and indigenous cosmologies, highly silenced, and, on the other, the modern and contemporary cosmology, seen as universal and homogenous. Tradition and Modern Reason are in contradiction, thus, in a dialog of political approximation and displacement for empowering subalternized alterities in the physical sciences—a place where white, male, hetero-cis-normative people dominate (Anteneodo et al., 2020).

The ethnic-racial conflicts discussed here involve scientific-technological projects to different global latitudes. They summarize epistemic confrontations that should be critically analyzed within the contexts of education and outreach of physical sciences. These discussions are not only identitarian, but they, above all, configure deep philosophical and epistemological questions which imply the actualization of participative democracy and the inclusive and non-cosmophobic perspective. The contextualization of the ethnic-racial conflicts is, for us, an opportunity of displacements and reflections about the presences and absences of Black, quilombola, and indigenous bodies in a Freirean perspective, able to hypothesize processes of humanization of education in sciences.

If, on the one hand, the Scientific Revolution framed in Europe has materialized a concept of science in line and articulated with mathematics and technologies in a visceral way, on the other hand, in the fringes of the 21st century, amid so many social and economic challenges pervading the Black, quilombola, and indigenous existences in Brazil, there should be an ongoing responsibility in early and continuous training of teachers and promoters in sciences in the sense of building other possible futures for Brazil, whose present is permeated by the past. This is a revolutionary ethic commitment that grounds Black, African, African-Brazilian, and Indigenous cosmologies and alterities.

The aims and methodological and epistemological bases of the Black, quilombola, and indigenous social movements are in line with the basic tenets of Critical Race Theory. These movements are genuinely educational, offering us, for physical sciences, innovative outlooks and perspectives, democratically freeing for the building of a more human science. We should disquiet ourselves and act, building other narratives in physical sciences, able to return humanity to bodies-territories thoughts in deep Brazil.

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NOTAS

1 We recognize that, historically and epistemologically speaking, there are many ways to conceive of Modern Science and Tradition.

2 We neither advocate nor work with the idea that there is only one existing scientific method.

3 Available at: https://revistapesquisa.fapesp.br/pronto-para-decolagem/ . Access in 25/11/2021.

4 Geopolitical concept used to describe the countries deemed as developed according to their socioeconomic characteristics. It should not be confused with geographical position, since, although Australia is located in the Southern Hemisphere, it belongs geopolitically to the Global North.

5 Available at: https://revistapesquisa.fapesp.br/a-miseria-que-cerca-alcantara/. Access in 25/11/2021.

6 An allusion to the decision of the Supreme Federal Court about the criteria for delimitation of quilombola lands in Brazil. In the case of the AQT, involved in the quilombola-CLA conflict, the same article reports that, in November 2019, the National Institute for Colonization and Agrarian Reform (Incra) destined 9.3 thousand hectares to the CLA and only 8.1 thousand to the quilombola descendants. Available at: https://revistapesquisa.fapesp.br/disputa-por-alcantara/. Access in 25/11/2021.

7 Available at: <https://cpisp.org.br/>. Access in 12/06/2022.

8 Available at: https://brasil.elpais.com/brasil/2015/09/22/politica/1442930391_549192.html. Access in 30/11/2021.

9 In astronomy, it measures the degree of degradation of an image due to atmospheric effects. One seeing of 0.8-1 second is considered the ideal arch of a classical/typical observation.

10 Available at: <https://epocanegocios.globo.com/Mundo/noticia/2019/12/como-o-chile-virou-capital-mundial-da-observacao-espacial.html>. Access in: 12/06/2022.

Alan Alves-Brito
Doutor em Ciências. Professor Adjunto - Instituto de Física da UFRGS. Participante do grupo de pesquisa do Programa de Pós-Graduação em Ensino de Física do Programa de Pós-Graduação em Física da UFRGS.
E-mail: alan.brito@ufrgs.br

Kaleb Ribeiro Alho
Doutorando em Ensino de Física. Estudante de Doutorado - Instituto de Física da UFRGS. Participante do grupo de pesquisa do Programa de Pós-Graduação em Ensino de Física da UFRGS.
E-mail: kalebalhofisica@gmail.com

Contato:
Universidade Federal do Rio Grande do Sul — Instituto de Física
Av. Bento Gonçalves 9500, Agronomia, Campus do Vale
Porto Alegre - RS | Brasil
CEP 91.501-970

Editor responsável:
Glauco dos Santos Ferreira da Silva

Contato:
Centro de Ensino de Ciências e Matemática de Minas Gerais – CECIMIG
Faculdade de Educação – Universidade Federal de Minas Gerais
revistaepec@gmail.com

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