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Indigenous Experimentation and Science Education in Dialogue[1]

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RESUMO

A ciência ocidental, com sua ênfase na experimentação controlada e na objetividade, trilhou um caminho distinto dos saberes ancestrais indígenas, arraigados em contextos específicos. Historicamente, essa dicotomia gerou um distanciamento entre esses dois campos de conhecimento. Diante disso, este estudo se propôs a mapear e analisar as discussões presentes na literatura acadêmica sobre experimentação e saberes indígenas, buscando compreender as perspectivas e reflexões que emergem dessa intersecção. A metodologia empregada foi a revisão sistemática de literatura, para coletar dados qualitativos e analisá-los sob a ótica da análise textual discursiva. A partir dessa análise, concluiu-se que a abordagem intercultural traz diversos benefícios para o ensino de ciências, como a contextualização dos conhecimentos, a formação crítica e cidadã, a pluralidade de ideias e a superação de ideias distorcidas sobre a ciência, promovendo uma educação mais emancipadora, com maior equidade e que valoriza a diversidade.

PALAVRAS-CHAVE: Saberes indígenas. Ensino de ciências. Experimentação. Interculturalidade.

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Exploring indigenous knowledge: a systematic review of experimentation and traditional knowledge

ABSTRACT

Western science, with its emphasis on controlled experimentation and objectivity, has followed a path distinct from Indigenous ancestral knowledge, which is deeply rooted in specific contexts. Historically, this dichotomy has created a separation between these two fields of knowledge. In this context, the present study aimed to map and analyze the discussions found in the academic literature on experimentation and Indigenous knowledge, seeking to understand the perspectives and reflections that emerge from this intersection. The methodology employed was a systematic literature review to collect qualitative data and analyze it through the lens of discursive textual analysis. Based on this analysis, it was concluded that an intercultural approach offers several benefits for science education, such as the contextualization of knowledge, the promotion of critical citizenship education, the fostering of a plurality of ideas, and the overcoming of distorted conceptions about science, thus promoting a more emancipatory education, with greater equity and an appreciation of diversity.

KEYWORDS: Indigenous knowledge. Science education. Experimentation. Intercultural education.

Explorando saberes indígenas: una revisión sistemática sobre experimentación y conocimientos tradicionales

RESUMEN

La ciencia occidental, con su énfasis en la experimentación controlada y en la objetividad, ha seguido un camino distinto al de los saberes ancestrales indígenas, arraigados en contextos específicos. Históricamente, esta dicotomía ha generado un distanciamiento entre estos dos campos del conocimiento. En este contexto, el presente estudio tuvo como objetivo mapear y analizar las discusiones presentes en la literatura académica sobre experimentación y saberes indígenas, buscando comprender las perspectivas y reflexiones que

emergen de esta intersección. La metodología empleada fue la revisión sistemática de la literatura, con el fin de recopilar datos cualitativos y analizarlos bajo la óptica del análisis textual discursivo. A partir de este análisis, se concluyó que el enfoque intercultural aporta diversos beneficios a la enseñanza de las ciencias, como la contextualización de los conocimientos, la formación crítica y ciudadana, la pluralidad de ideas y la superación de concepciones distorsionadas sobre la ciencia, promoviendo así una educación más emancipadora, con mayor equidad y que valore la diversidad.

PALABRAS CLAVE: Saberes indígenas. Enseñanza de ciencias. Experimentación. Interculturalidad.

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Introduction

Scientific experimentation and Indigenous knowledge are fields of thought that have historically followed distinct trajectories. Western science, with its focus on controlled experimentation and objectivity, has often distanced itself from traditional wisdom, which is deeply rooted in specific cultural, spiritual, and ecological contexts. However, in recent decades, there has been a growing recognition of the richness and relevance of Indigenous knowledge, particularly in areas such as biodiversity, traditional medicine, and the sustainable management of natural resources.

Indigenous knowledge is characterized by a holistic and interconnected approach to the natural world, often transmitted orally and through community practices. It offers unique perspectives on the relationship between humans and nature, which can complement and enrich traditional scientific approaches. This recognition has driven a series of studies and collaborative projects that seek to integrate such knowledge with scientific experimentation to address global challenges such as climate change, biodiversity loss, and public health (Maia & Araújo, 2015).

Despite this trend, the integration of Indigenous knowledge into scientific research faces significant challenges. One of the main obstacles lies in the fundamental differences between the epistemological foundations that underpin these two systems of knowledge. While Western science tends to value quantification, repeatability, and objectivity, Indigenous knowledge often relies on personal experiences, cultural contexts, and interdependence with the environment.

This disparity is rooted in the historical construction of the concept of modernity, shaped by Eurocentric conceptions. Such a concept imposed a worldview centered on reason, individuality, and European knowledge as the universal standard, relegating other cultures to the margins and categorizing them as "different," "primitive," and "pre-modern." This Eurocentric view of modernity subjugates those who deviate from the Western notion of "man," classifying them as subhuman and inferior. This ethnocentric stance constitutes an additional challenge to the integration of Indigenous knowledge, as it disregards the richness and validity of those ways of knowing (Loureiro & Moretti, 2021).

In this context, it becomes crucial to conduct an in-depth examination of how academic studies are addressing experimentation and the incorporation of these traditional forms of knowledge. In such an analysis, it is essential to uncover the ongoing discussions and understand how they shape the ways in which ancestral knowledge is integrated and valued.

This systematic review article aims to map and analyze the discussions present in the academic literature on experimentation and Indigenous knowledge, compare different theoretical perspectives adopted in these studies, and assess how these discussions precede the recognition and integration of Indigenous knowledge into scientific research. The guiding research question of this work is: What do academic articles addressing experimentation and Indigenous knowledge reveal?

By answering this question, we intend to provide an overview of current approaches, identify gaps in knowledge, and offer recommendations for future research and practices that foster a more equitable and fruitful dialogue between science and Indigenous knowledge.

Weaving the web of knowledge: theoretical foundations

Grounded in the multicultural perspective of the Natural Sciences, this study seeks to investigate the connections between Indigenous knowledge and experimentation in science education. This section presents the main theoretical concepts that underpin this proposal, such as the principles of multicultural education, the importance of valuing Indigenous knowledge in science teaching, and the role of experimentation as a tool for constructing intercultural scientific knowledge.

Within the multicultural approach, the aim is to overcome the prevailing Eurocentric view in the Natural Sciences, which often ignores or marginalizes the contributions of other cultures. It is therefore essential to foster ethnic and cultural literacy among students, including the history and contributions of marginalized groups, valuing diversity, promoting personal empowerment, cultivating attitudes, values, habits, and skills so that individuals may become agents of social change committed to societal reform (Ogunleye, 2009).

In this movement, the epistemologies of the South emerge as an alternative to the prevailing hegemony in school education, which remains dominant today. These epistemologies are necessary because those of the North claim universality (Santos, Araújo & Baumgarten, 2016).

Universalism positions the so-called “modern science” as superior, while traditional knowledge is considered merely alternative to scientific knowledge, differing in fundamental aspects and relegated to the status of primitive, esoteric, and invalid (Hansson, 2018).

To overcome this view, it is necessary to understand the incompleteness of all forms of knowledge, including scientific knowledge, not in the sense of disregarding the relevance of science, but as a way to achieve plurality, interaction, and complementarity among diverse knowledge systems (Santos, Araújo & Baumgarten, 2016).

In this work, Indigenous knowledge is recognized as a complex set of understandings, the result of empirical observations and experiences accumulated over generations. These forms of knowledge encompass various domains, including biology, astronomy, medicine, and agriculture, and can provide valuable contributions to science education.

Authors such as Hansson (2018) contribute to this understanding by using the term "fact-finding" to define one of the characteristics of scientific knowledge construction. Such practices can be found in diverse societies, such as the systematization of hunting and tracking, which requires hypothesis formulation and subsequent group discussion/acceptance after testing.

The same author further argues that experimental practice is not limited to the pursuit of understanding nature but is also guided by societal needs, which he calls "directly action-guiding experiments". Thus, many ancestral societies employed experiments, with agriculture being the primary example cited.

According to Giordan (1999), modern scientific methodology, which is based on the rationalization of procedures, induction, and deduction, grants experimentation a prominent role. This emphasis can lead to a dichotomy with the production of ancestral knowledge, which relies on diverse methods, contextualized understandings, and a holistic worldview.

To overcome this dichotomy, it is essential to recognize that experimentation is not merely the passive manipulation of nature but rather an active process of engagement with the world, guided by hypotheses and questions. The view of science, and consequently of experimental activity, as neutral and decontextualized is a distorted perspective that ignores its complex relations with society (Cachapuz et al., 2005).

Currently, experimental classes go beyond the mere reproduction of procedures. They should assist in understanding the nature of science, developing social skills for group work, stimulating creativity, and enhancing observational capacity (Oliveira, 2010). To achieve this, it is fundamental to consider diverse perspectives on knowledge production, including ancestral knowledge.

In this context, experimentation assumes a crucial role as a tool for constructing scientific knowledge. By enabling students to engage in practical experimentation, the aim is to foster dialogue between Indigenous knowledge and Western scientific knowledge, promoting respect for cultural diversity and building a more just and inclusive education.

Methodological Procedures

This systematic literature review employed a qualitative approach through Discursive Textual Analysis (DTA) to examine the presence and discussion of Indigenous knowledge and experimentation in science education within academic articles. DTA was chosen for its ability to explore and interpret underlying meanings in texts, as well as to identify discursive patterns.

As argued by Moraes and Galiazzi (2006), DTA allows the researcher to interpret the meanings attributed by authors in texts through a hermeneutic exercise, thereby fostering a deeper understanding of their content, which makes it an appropriate methodological tool for this study. This methodology is characterized by a detailed and profound unitarization process, in which the text is divided into units of meaning according to the theme, objectives, and research problem. Subsequently, similar meanings are articulated in the categorization process, organizing emerging and final categories from the units of meaning.

In line with Romanowski and Ens (2006), during the search stage, a state-of-the-art survey was conducted on the topic, recognizing its importance as a fundamental step in the qualitative analysis process. Accordingly, the following procedures were adopted:

- **Definition of descriptors**: Keywords and terms relevant to the research theme were selected according to the objectives, namely "Indigenous knowledge," "science education," and "experimentation." Search strategies were adapted for each database, using combinations of keywords and Boolean operators to refine results.
- **Selection of databases**: Searches were conducted in several scientific literature repositories, such as the Brazilian Portal of Open Access Scientific Publications and Data (Oasisbr), CAPES journals, Scopus, and Google Scholar. Due to the low number of results, the Brazilian Digital Library of Theses and Dissertations (BDTD) was also included.
- **Establishment of selection criteria**: Searches were carried out between June 27 and July 2, 2024, and the period analyzed began in 2008, coinciding with the enactment of Law No. 11.645/2008, which mandated the inclusion of Afro-Brazilian and Indigenous history and culture in school curricula. Furthermore, studies had to explicitly address Indigenous knowledge and experimentation.
- **Systematization and analysis**: The articles found were initially filtered by title and abstract. Those meeting the inclusion criteria were selected for full reading. Subsequently, the articles were analyzed in depth to ensure relevance and alignment with the study's focus.

Through these steps, five articles, two theses, and four dissertations were selected to constitute the corpus of analysis, as shown in Table 1.

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TABLE 1 – Articles selected for the corpus of analysis

Code	Authors	Title	Year
A1	FARY, Bruna Adriane, POLIZEL Alexandre Luiz, OLIVEIRA, Moisés Alves, SAVIOLI, Angela Marta Pereira das Dores	*Modos de (re)pensar a experimentação e seus ensinos*	2021
A2	ANESIO , Isabela Lira, LIMA, Mikeas Silva, FARIAS, Fellipe Freire Santos, BRAGA, Cláudia de Figueiredo	*A cultura indígena no ensino de química: uma proposta de sequência didática*	2022
A3	LOPES, Ketila Kaliane Bacelar Brito, ARAUJO, Maise Ribeiro, COSTA, Franciellen Rodrigues da Silva	*Os caminhos do Arandu até o Kimistari: relações étnico-raciais no ensino de química através de oficinas temáticas*	2023
A4	VASCONCELOS, Gabriel Brabo, CARDOSO, Carlos Eduardo Tolosa, SOUZA, Agerdânio Andrade, LEITE, Maria Adriana	*De Michael Faraday as aldeias do Oiapoque-AP: protótipo de motor monocilindro movido a bobina solenoide contribuindo na formação de professores indígenas*	2020
A5	VANUCHI, Vânia Costa Ferreira, WELTER, Luiz Eduardo Welter, STEFANELLO, Luiza Bertoldo, BRAIBANTE, Mara Elisa Fortes	*Oficina temática "tintas indígenas": ensino de ciências por meio da temática "indígena"*	2019
T1	SILVA, Juvan Pereira da	*Estudos sobre a formação de professores de química numa disciplina experimental com abordagem cultural diaspórica*	2020
T2	SOUZA, Vitor Fabricio Machado	*O hálito das palavras: ciências (multi) naturais contra o preconceito.*	2020
D1	GONZAGA, Kézia Ribeiro	*A experimentação no ensino de química e os saberes indígenas*	2020
D2	VANUCHI, Vânia Costa Ferreira	*Corantes naturais da cultura indígena no ensino de química*	2019
D3	SILVA, Francisco Américo da	*Um curso de física aplicado à educação escolar indígena*	2016
D4	VIEIRA, Antonio Jadson Gomes	*Práticas motivadoras para a aprendizagem da mecânica para estudantes do ensino médio, contextualizadas no ensino das ciências ambientais*	2021

Source: the authors (2024).

Discursive textual analysis was subsequently conducted through the following stages:

I. **Identification of Context Units**: In this stage, paragraphs or sentences from the articles that directly or indirectly addressed the research theme were identified. To this end, a close reading of the texts was performed, highlighting the units of analysis related to the object of study.

II. **Identification of Categories**: Following the selection of relevant context units, an in-depth analysis was conducted, deconstructing the texts to identify categories and subcategories emerging from the data. This involved an intensive reading of each context unit to identify recurring patterns and themes, followed by the coding of these units according to the identified themes. Finally, the context units were grouped into categories and subcategories representing the primary themes and concepts present in the texts.

III. **Construction of Metatexts**: Based on the identified categories and subcategories, metatexts were developed, consisting of reconstructions of the original texts that interpret the underlying meanings and discourses related to the research theme. Accordingly, the relationships between categories and subcategories were analyzed, identifying the discourses within the texts to construct a new synthesis that encapsulates the primary implications of the study.

Results and Discussion

Upon analyzing the research results, two aspects immediately stand out: the scarcity of studies that relate Indigenous knowledge to experimentation and the recent emergence of this theme as a research focus, since nearly all works were published after 2019, with the exception of a single study from 2016.

Table 2 summarizes the search results, corroborating the finding that there is a relatively small number of studies exploring this theme within science education.

TABLE 2 – Number of articles on experimentation and Indigenous knowledge

Databases	Number of articles on Experimentation science education	Number of articles after filtering with the term "Indigenous"	Number of articles that meet the criteria of the study
Oasisbr	601	3	1
CAPES	1466	5	1
Google Scholar	488	111	3
BDTD	1168	28	6

Source: the authors (2024).

This scarcity of research can be partially explained by historical and social factors. As Silva (2019) points out, there is a lack of teaching materials to support the inclusion of Indigenous history and culture in Brazilian schools. Despite Law 11.645/2008, which mandates the inclusion of Afro-Brazilian and Indigenous history and culture in school curricula, its implementation remains incipient and fragmented, as reflected in the limited academic production on the subject.

To illustrate this scarcity, some studies have mapped scientific production in the field. Silva and Ayres (2019) analyzed articles published in science education journals that addressed human diversity and ethnic-racial relations. Out of 2,401 articles, only nine dealt with the theme of Ethnic-Racial Relations and Science Education, corresponding to just 0.37% of the total.

Similarly, Silva and Neto (2023) examined the proceedings of the National Meeting on Research in Science Education (ENPEC) between 2005 and 2021. Their study sought to identify the epistemological interests of science education researchers in the debate on ethnic-racial relations. Despite the enactment of laws in 2003 and 2008, the authors observed a significant increase in the theme only after 2013. They found 22 studies on Education for Ethnic-Racial Relations (ERER) and science education, and six studies focusing on teacher training.

Pereira (2022) highlights another factor contributing to the scarcity of research: the lack of effective enforcement of Law 11.645/2008. This gap has

led to a tendency of folklorization of African and Indigenous culture, marked by sporadic events on commemorative dates such as Black Consciousness Day, and by superficial applications of themes that, although addressed, are not adequately problematized.

As Severo et al. (2022) emphasize, this situation can be explained by the historical process of colonialism, which subordinated colonized peoples in their culture and epistemologies, resulting in the erasure of their knowledge.

Therefore, this reality demands a collective effort to foster research that explores the intersection between Indigenous knowledge and experimentation in science education. Such initiatives are crucial to enrich school curricula, promote intercultural dialogue, and build a more just and inclusive education.

For better organization of the data, based on Guidotti and Heckler (2023), the units of meaning were organized into a spreadsheet, duly coded and accompanied by a brief description of each study. Codes refer to articles (A), theses (T), or dissertations (D) analyzed, to the units extracted from the texts (U), and to the emerging intermediate categories (IC).

The search for units of meaning included pedagogies or theories that supported the research, conceptions and methodologies of experimentation applied, the context of the target audience, and the results obtained.

TABLE 3 – Excerpt from the data coding table

Code	Units of meaning	Description
A1.U1.IC1	The laboratory is conceived as any space capable of facilitating experimentation.	The article is a theoretical essay that offers considerations regarding different modes of conducting experimentation – namely traditional, critical, and post-critical approaches. It aims to rethink the current understandings of experimentation and laboratory, while exploring the application of post-critical experimentation.
A1.U2.IC3	Experimentation as an exercise for the understanding and comprehension of natural phenomena.	
A1.U3.IC1	Interdisciplinary spaces that can foster moments of contextualization within students' daily lives.	

Source: the authors (2024).

In the categorization stage, by articulating meanings, four final categories emerged: I) Spaces, dialogues, and approaches to experimentation, II) Theoretical foundations and interfaces, III) Transversal themes or curricular change and IV) Valuing Indigenous worldviews, as shown in Table 4.

TABLE 4 – Emerging categories interconnected with intermediate categories

Intermediate Categories	**Category I: Spaces, dialogues, and approaches to experimentation**	**Code**
	Laboratory conceived as any space capable of facilitating experimentation	IC1
	Experimental guide	IC2
	Experimentation as an exercise for the understanding and comprehension of natural phenomena	IC3
	Inquiry-based science education	IC4
	Workshops utilizing the three pedagogical moments	IC5
Intermediate Categories	**Category II: Theoretical foundations and interfaces**	
	Traditional, critical, and post-critical pedagogies, and Paulo Freire	IC6
	Multiculturality and interculturality	IC7
	Lack of depth in theoretical foundations	IC8
	Myth of modernity and universality	IC9
	Meaningful learning	IC10
	Vergnaud's theory of conceptual fields	IC11
	Discussions on the nature and philosophy of science	IC12
Intermediate Categories	**Category III: Transversal themes or curricular change**	
	Indigenous knowledge as transversal themes	IC13
	Indigenous knowledge integrated into the curriculum	IC14
	Activities developed in Indigenous schools	IC15
Intermediate Categories	**Category IV: Valuing Indigenous worldviews**	
	Critique of the universalist production of knowledge	IC16
	Facilitator for contextualization	IC17
	Critical citizenship education	IC18

Source: the authors (2024).

The systematization of intermediate categories and their interrelationships facilitates the construction of a synthesis and the interpretation of the studies through metatexts, which will be explored below.

I. Spaces, dialogues, and approaches to experimentation

During the reading of the articles, common aspects observed across several works, that are aligned with the objectives of this research, were discussions related to the flexibility of spaces in which experimentation can take place, the presence or absence of a predefined guide, the relationships between theory and practice, and the types of experimentation as teaching strategies.

Studies A1, D2, and D4 explore the implementation of practical activities in diverse contexts, expanding learning opportunities and connecting science to students' realities. Rather than being restricted to formal environments such as laboratories, experimentation extends to interdisciplinary spaces, where the world itself becomes a broad and diversified laboratory.

Studies A2, D1, and D4 employ scripts in the development of activities. However, the rigidity of a predefined guide is not always necessary. Experimentation can be guided by objectives and questions, allowing students to explore, make discoveries, and construct their own knowledge. This flexible approach goes beyond the mere application of a script, enabling more active, critical, and meaningful learning.

It is important to emphasize that the critique of rigid guides does not aim to invalidate them. The objective is to question the colonial forms implicitly embedded in their use, even in contexts that claim to be decolonial.

Study D2 exemplifies this critique by stating that experimentation based on "ready-made recipes" does not align with current teaching practices. In other words, expecting predefined results limits exploration and discovery, contradicting the principle of stimulating skills beyond procedural ones.

Instead of following rigid guides, experimentation can be a process of knowledge construction, where students assume an active and leading role. In this case, it is fundamental to seek alternatives that promote a more emancipatory, contextualized, and meaningful learning.

Regarding the interconnection between theory and practice, studies A3, A4, and D2 highlight that experimentation transcends the mere application of techniques, becoming a process of active knowledge construction. Students take on the central role, testing hypotheses, analyzing results, and critically reflecting on the relationships between theory and practice. This approach promotes deeper, more meaningful, and contextualized learning, positively impacting the teaching and learning process as a whole.

Dissertation D4, on the other hand, argues that activities demonstrating concepts can be important for content assimilation and for encouraging students to seek solutions to everyday situations. Although its conjectures are relevant, it is crucial to critically analyze possible traces of colonial thinking present in this approach.

Traditional teaching, often grounded in a colonial view of knowledge, tends to use experimentation merely as a tool to prove theories and reinforce content. This perspective limits the potential of experimentation, preventing the development of critical and autonomous thinking among students.

Experimentation takes on diverse forms, ranging from simple exploratory activities to complex research projects. This variety allows teachers to adapt activities to different learning objectives and student characteristics. Although the description of the strategy used is fundamental for understanding the work, only study D1 explicitly defines "inquiry-based teaching" as its methodological foundation. Works A3, A4, A5, and D2 mention the use of workshops but do not detail the type of experimentation employed.

Oliveira (2010) categorizes experimental activities into demonstration, verification, and investigation. This categorization helps teachers choose the most appropriate method for their objectives, considering the skills to be developed and the resources available. Critically understanding the differences between methods is essential for their effective application.

Study D1, which opted for investigation, had advantages according to Oliveira (2010): students assumed a more active role, had space to exercise creativity, and, above all, found it easier to address socially relevant themes, such as Indigenous knowledge.

Experimentation, in its various forms, emerges as a powerful tool for science education. When enriched by a multicultural approach that integrates Indigenous ancestral knowledge, this tool becomes even more transformative, opening a wide range of possibilities for education.

The multicultural approach breaks with the monotony of traditional education, contextualizing scientific knowledge within students' realities. By connecting science with Indigenous knowledge, experimentation becomes more meaningful and relevant to students' lives, opening doors to intercultural dialogue and the appreciation of diversity.

II. Theoretical foundations and interfaces

From the outset of this review, the analysis of the theories that underpin the discussions present in the selected studies was a crucial element. Delving into these theoretical foundations is essential for understanding the phenomenon in question, allowing for a broader and more critical analysis.

When categorizing the theories employed, we found a rich mosaic of perspectives supporting the research, among which the most recurrent were: critical pedagogy, anchored in Paulo Freire as the principal theorist; multiculturality and interculturality; and various discussions on the nature and philosophy of science.

It is important to emphasize that, although these theories are present in several studies, some of them were not sufficiently developed. This lack of depth may compromise the quality of the analysis and the understanding of the phenomenon under study.

Within the scope of education for ethnic-racial relations, one concept under constant debate and critique is that of modernity. Constructed from Eurocentric conceptions, modernity imposed a worldview centered on reason, the individual, and European knowledge as the universal standard, relegating other cultures to categories such as "different," "primitive," and "pre-modern." Such a view subjugates those who deviate from the philosophical notion of "man," classifying them as subhuman and inferior (Loureiro & Moretti, 2021).

In line with this critique, the work of Paulo Freire, cited in A1, A3, and A4, denounces dehumanization, a concept that decolonial studies refer to as the coloniality of being. Freire argues that traditional education, often Eurocentric and colonial, contributes to the dehumanization of marginalized individuals and groups, perpetuating inequalities and oppressive power relations.

Another interesting connection that can be established is the one between the culture of silence and the decolonial rupture with modernity. This silence is not limited to the physical act of speech but extends to ways of thinking and acting based on one's own enunciations of the world. The epistemologies of the colonized were silenced and subjugated by the colonizers, who imposed their worldview as the sole and definitive truth (Loureiro & Moretti, 2021).

To confront this reality, a critical and emancipatory science education is necessary, one that promotes reflection on the historical process of constructing science, including the deconstruction of distorted views that permeate it. Such an education must consider the different contexts, modes of production, subjectivities, and interests involved in the construction of scientific knowledge. It is crucial to recognize that science

is not neutral and that its construction is intrinsically linked to power relations and existing social structures (Oliveira & Von Linsingen, 2021).

In the search for counter-hegemonic knowledge, many researchers advocate for the appreciation of epistemologies of the South, a term encompassing a variety of approaches aimed at repairing the historical damage caused by colonial capitalism. Among the decolonial epistemological proposals discussed are critical interculturality, transmodernity, and the ecology of knowledge (Oliveira & Von Linsingen, 2021).

The epistemologies of the South, whether multicultural or intercultural, were observed in studies A2, A4, D1, D3, and T2. This prominence may be due to the fact that critical interculturality, of a counter-hegemonic nature, seeks not only to denounce but also to transform reality and existing epistemologies. It goes beyond governmental or academic discourse, implementing alternative epistemologies and methodologies that break with the status quo and promote significant change (Caurio, Cassiani & Giraldi, 2021).

Uribe-Pérez (2020) found that pre-service teachers in natural sciences believe that interculturality should be promoted in all spheres of education, not only in schools located in rural areas and Indigenous or Afro-descendant communities. They understand interculturality as encounters, exchanges, and correlations between different cultures, which becomes challenging in a hegemonic system where one culture imposes itself over others. This perspective is reflected in thesis T1, which retells history without disregarding the knowledge of the colonizers, as they did with that of the colonized. Interculturality, as observed in A4, encourages progress in formal education through the interrelation between Indigenous and academic knowledge.

However, it is necessary to remain vigilant so as not to perpetuate stereotypes of a single and absolute reason, attempting to validate ancestral knowledge only through modern science. Making superficial correlations that seek to grant knowledge considered inferior a status of

adequacy merely because it fits within the definitions of modern science is not the path toward true appreciation of ancestral knowledge.

Thus, it is evident that maintaining a Eurocentric curriculum in schools perpetuates mechanisms of exclusion in society, reinforcing inequalities among different social groups. By promoting the decolonization of knowledge and the appreciation of diverse epistemologies, we can contribute to the construction of a more just, inclusive, and emancipatory education.

III Transversal themes or curricular change?

Ancestral knowledge, whether African or Indigenous, are often treated as transversal themes. According to Wenceslau and Silva (2017), these themes are related to contents of social nature, being addressed across various areas of the curriculum. Among the studies analyzed, Indigenous knowledge appeared as transversal themes in A2, A5, D2, and T2.

On the other hand, studies A2, D1, D2, T1, and T2 emphasize the importance of integrating ancestral knowledge into the school curriculum. Thesis T1, for example, asserts that it is urgent to discuss Afro-Brazilian culture in all undergraduate programs, especially in teacher education, so that this knowledge may also be implemented in basic education.

Wenceslau and Silva (2017) criticize the curricular integration of transversal themes, arguing that, when transformed into disciplinary content, they become detached from social reality and the formation of subjectivities, remaining aligned with domination and control. However, the authors defend that these themes should permeate the entire curriculum and be addressed in conjunction with all disciplines. In practice, particularly in the natural sciences, the inclusion of Afro and Indigenous cultures in the content is rarely observed.

As an example, one may cite the study by Souza and Barbosa (2021), which investigated whether the chemistry teacher education program at the *Instituto Federal de Educação, Ciência e Tecnologia Baiano*[6] (IF Baiano), Catu Campus, had plans and practices aimed at ERER. The researchers interviewed students and analyzed the Pedagogical Project of the Course (PPC). Many students recalled discussions that occurred mainly within the Center for Afro-Brazilian and Indigenous Studies (NEABI), but since these were extracurricular activities, they did not reach all pre-service teachers. Regarding regular courses, students believed that ethnic-racial relations were addressed briefly and with little class time, resulting in superficial knowledge of the subject.

When addressing ERER as a theme, dissertation D2 discussed the importance of curricular change, explaining that the thematic approach should not merely present chemical content or provide information about technological processes, but rather insert information and concepts into reality, evaluating situations and solutions as a form of social intervention.

In this context, it is important to highlight that A4, D3, and T2 were studies conducted in Indigenous schools, and that A2 included students from Indigenous communities. It is essential to address Indigenous knowledge with protagonism in these settings, but it is equally crucial to incorporate it into regular schools, both to enrich students' knowledge and to foster a more critical, plural, and emancipatory education.

IV. Valuing Indigenous worldviews

The conception of science as a neutral and universal form of knowledge has been increasingly questioned. Several studies explore the importance of science in the emancipatory process, recognizing it as a complex human construction that goes beyond the mere accumulation of knowledge.

[6]Free translation: Federal Institute of Education, Science and Technology from the State of Bahia.

Approaching science in a critical and emancipatory way requires going beyond the conceptual aspect. It is essential to consider the historical, social, and philosophical analyses that permeate the construction of scientific knowledge. By understanding that science is not neutral and that its knowledge is the product of specific contexts, we can uncover how it may contribute either to the reproduction or to the deconstruction of racial hierarchies and ethnic discrimination.

In this context, studies A1, A3, and A5 criticize the idea of a single valid production of knowledge. These works seek to value traditional knowledge and question the hegemony of modern Western science. Traditional science education often perpetuates colonial and racist structures, as discussed throughout this text. Modern Western science, frequently regarded as the sole holder of reason and the scientific method, ignores or devalues ancestral knowledge, even though such knowledge has significantly contributed to its own development throughout history.

In this regard, Coelho and Silva (2019) present theoretical reflections on the political role of science and its contribution to citizenship formation. They question the Eurocentric structures of scientific knowledge, exposing how it has been used to promote racist ideas. Furthermore, they advocate for the inclusion of ERER in the science curriculum, with the aim of redefining the hegemonic structure of science propagated in school education.

Article A3 corroborates this critique, affirming that schools, by neglecting the history and scientific advances of non-European peoples, tend to create a distorted image of science, reinforcing Eurocentric hegemony and perpetuating inequalities.

To overcome these views, contextualized teaching is essential. Research in science education shows that a decontextualized and uncritical approach not only limits but also undermines the education of 21st-century students (Silva & Ayres, 2019).

In this context, education for ethnic-racial relations emerges as a fundamental element for contextualizing science teaching. By integrating ethnic-racial perspectives into science education, students are empowered to understand the complex relationships between science, society, culture, and power. They develop the ability to critically analyze how social, historical, and political dynamics influence both the production and application of scientific knowledge.

Among the studies analyzed, A3, A4, A5, D1, D2, D3, and D4 demonstrate how the integration of Indigenous knowledge can contribute to the contextualization of science teaching. This integration promotes an intercultural approach in which scientific and Indigenous knowledge are valued and brought into dialogue.

Study D3, for example, highlights the importance of fostering student participation in the construction of scientific knowledge. By introducing Indigenous knowledge, initial dialogues should be built upon students' own experiences and life contexts, bringing them closer to scientific concepts in an intercultural way.

The adoption of a contextualized and intercultural approach in science education is fundamental for the formation of citizens who are conscious and engaged in building a more just and inclusive society. Studies A2, A4, D2, and T2 report the development of critical citizenship education as a result of applying experimentation from the perspective of Indigenous knowledge.

Within the scope of ERER in science education, the work of Verrangia and Silva (2010) stands out. The authors advocate for an education oriented toward citizenship, in line with various guiding documents such as the National Curriculum Parameters (PCN) and teaching trends such as STSE (Science, Technology, Society, and Environment). They discuss the relevance of ERER for an emancipatory education and the role of science teaching in this context.

To value traditional knowledge is to contribute towards an anti-racist education. By introducing new intercultural tools into scientific knowledge, schools enable the construction of a more critical citizenship, grounded in reflection and interaction with society.

Final Considerations

By weaving together the threads that interconnect experimentation with the richness of Indigenous knowledge, we seek to open a portal for reflections on a truly emancipatory education, in which the diversity of knowledge may flourish and science may become an instrument of social transformation.

Although the number of studies is still limited, the results found demonstrate the importance and relevance of the theme. The analyzed research is grounded in and corroborates decolonial theories, emphasizing the need to recognize knowledge and worldviews beyond Eurocentric perspectives. The latter, often imposed in school education, favor the maintenance of a hegemonic and exclusionary curriculum.

The intercultural approach, as observed in the results, brings several benefits to science education. Among them, we highlight the contextualization of knowledge, the promotion of a critical citizenship education, the plurality of ideas, and the overcoming of distorted conceptions of science. As a consequence, a more emancipatory education is fostered, one that promotes greater equity and values diversity.

We suggest that future research explore different methodologies, expand the spaces studied, including regular schools, and seek partnerships with Indigenous communities and institutions to strengthen research in this area.

We hope that the flame of intercultural experimentation will continue to illuminate the future, inspiring generations to recognize ancestral wisdom and to build a school in which all forms of knowledge are valued and respected and where the construction of a more just, inclusive, and sustainable society for all is the main goal.

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