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Intercultural Science Education: A Systematic Review of the Literature on Science Teaching

Educação Científica Intercultural: Uma Revisão Sistemática da Literatura da Produção no Ensino de Ciências

Educación Científica Intercultural: Una Revisión Sistemática de la Literatura en Enseñanza de Ciencias

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Abstract

The historical valorization of scientific knowledge, to the detriment of equally legitimate ways of interpreting reality, has contributed to the silencing and invisibility of knowledge and sociocultural groups. In contrast to this reality, Intercultural Science Education (ISE) has emerged. In this regard, we seek to understand the definition, characterization, development, and challenges of Intercultural Science Education in science teaching, with the aim of inspiring educators to adopt this perspective. To this end, we conducted a Systematic Literature Review (SLR), synthesizing information and recommendations to contribute to this process. Thus, the study consists of an SLR derived from an excerpt of a doctoral research project. We used 50 articles published between 2014 and 2024 in the databases Scopus, Web of Science, Dialnet, and the Network of Scientific Journals of Latin America and the Caribbean, Spain, and Portugal (Redalyc). Regarding the definition, we identified that ISE is an approach sensitive to cultural diversity and is therefore characterized as a space for dialogue between knowledge systems facilitated by convergences, but which also reaffirms and engages with differences. ISE has been developed prominently in the Global South, from different perspectives, including valuing traditional communities, bilingualism, and immigrant integration. These perspectives are developed through ethnobiology, the creation of teaching materials, Communities of Practice, and teacher training. Regarding the challenges, we highlight structural and institutional barriers, teacher training, a lack of university-school rapprochement, and difficulties in cultural mediation.

Keywords: interculturality, scientific knowledge, diversity, science teaching

Resumo

A valorização histórica do conhecimento científico, em detrimento de formas também legítimas de interpretar a realidade, contribuiu para o silenciamento e invisibilização de saberes e grupos socioculturais. Em contraponto a essa realidade, surge a Educação Científica Intercultural (ECI). Nesse sentido, buscamos compreender a definição, a caracterização, o desenvolvimento e os desafios da Educação Científica Intercultural no ensino de ciências, a fim de inspirar educadores à adoção dessa perspectiva. Para tanto, realizamos uma Revisão Sistemática da Literatura, sintetizando informações e recomendações para colaborar com esse processo. Desse modo, o estudo consiste em uma RSL proveniente de um recorte de uma pesquisa de doutorado. Para sua produção utilizamos 50 artigos publicados entre os anos 2014 e 2024 nas bases de dados Scopus, Web of Science, Dialnet e Rede de Revistas Científicas da América Latina e Caribe, Espanha e Portugal (Redalyc). Quanto à definição, identificamos que a ECI é uma atitude sensível à diversidade cultural e se caracteriza, portanto, como um espaço de diálogo entre sistemas de conhecimento facilitado pelas convergências, mas que também reafirma e se engaja com as diferenças. A ECI tem sido desenvolvida com destaque no Sul Global, e sob diferentes

perspectivas: valorização das comunidades tradicionais, bilinguismo e integração de imigrantes, sendo tais perspectivas desenvolvidas através da Etnobiologia, criação de materiais didáticos, Comunidades de Prática e formação de professores. Quanto aos desafios, destacamos barreiras estruturais e institucionais, formação docente, falta de aproximação Universidade-Escola e dificuldades na mediação cultural.

Palavras-chave: interculturalidade, conhecimento científico, diversidade, ensino de ciências

Resumen

La valorización histórica del conocimiento científico, en detrimento de formas igualmente legítimas de interpretar la realidad, ha contribuido al silenciamiento e invisibilización de saberes y grupos socioculturales. En contraste con esta realidad, ha surgido la Educación Científica Intercultural (ECI). En este sentido, buscamos comprender la definición, caracterización, desarrollo y desafíos de la Educación Científica Intercultural en la educación científica, con el objetivo de inspirar a los educadores a adoptar esta perspectiva. Para ello, realizamos una Revisión Sistemática de la Literatura, sintetizando información y recomendaciones para contribuir a este proceso. Así, el estudio consiste en una RSL derivada de una parte de un proyecto de investigación doctoral. Utilizamos 50 artículos publicados entre 2014 y 2024 en las bases de datos Scopus, Web of Science, Dialnet y la Red de Revistas Científicas de América Latina y el Caribe, España y Portugal (Redalyc). En cuanto a la definición, identificamos que la ECI es un enfoque sensible a la diversidad cultural y, por lo tanto, se caracteriza por ser un espacio de diálogo entre sistemas de conocimiento, facilitado por las convergencias, pero que también reafirma y aborda las diferencias. La ECI se ha desarrollado de forma destacada en el Sur Global desde diferentes perspectivas: la valoración de las comunidades tradicionales, el bilingüismo y la integración de los inmigrantes. Estas perspectivas se desarrollan a través de la etnobiología, la creación de materiales didácticos, las comunidades de práctica y la formación docente. En cuanto a los desafíos, destacamos las barreras estructurales e institucionales, la formación docente, la falta de acercamiento entre la universidad y la escuela, y las dificultades en la mediación cultural.

Palabras clave: interculturalidad, conocimiento científico, diversidad, educación científica

Introduction

Historically, science education has been marked by a homogeneous view of the classroom (Peñaloza et al., 2023) and by the valorization of scientific knowledge as the only valid source of knowledge (Kato et al., 2023; Vergara & Albanese, 2022). These marks relegate situated and legitimate ways of understanding and interacting with the natural world, of interpreting reality, to a subordinate position (Baptista & Araújo, 2019).

In Latin America, which is recognized for its biological and cultural diversity (Peñaloza et al., 2023), this scientific hegemony marginalizes the knowledge and practices of traditional communities, such as artisanal fishermen, farmers, *caiçaras*, *quilombolas*, and indigenous people (Baptista & Araújo, 2019). Even with this exclusion, such communities resist, preserving their knowledge through cultural practices materialized in literature, music, dances, celebrations, clothing, religions, and cuisine, for example (Baptista & Araújo, 2019).

Despite this diversity and the richness that this implies, when these forms of knowledge are taught in the school, they are often treated in an "inferior" way, as knowledge of low social value (Franco & Ramírez, 2016). They are ignored in curricula that reinforce a universalist view of science (Martins et al., 2021). This may occur because teachers have not received training sensitive to cultural diversity (Amorim & Batista, 2019).

In this context, Intercultural Science Education (ISE) develops as an attitude that seeks to promote approximation and dialogue between invisible knowledge and scientific knowledge, as a way of recognizing, valuing, and respecting cultural diversity (Franco & Ramírez, 2016). This is especially important in traditional communities and school contexts where their knowledge is in a historical process of silencing and invisibilization because they are not recognized as legitimate ways of interpreting reality (Baptista & Molina-Andrade, 2021; Baptista et al., 2023).

Based on this and seeking to understand the definition, characterization, development, and challenges of Intercultural Science Education in science teaching, in order to inspire educators to adopt this perspective, we conducted a Systematic Literature Review, synthesizing information and recommendations to collaborate with this process.

From the delimitation of the objective, we then structured the search protocol based on the following guiding question: How is Intercultural Science Education defined, characterized, and developed by authors who have carried out experiences of Interculturality in the context of science education, and what challenges affect its development?

To answer this question, we structured the SLR in eight steps, based on the guidelines of Campos et al. (2023), Galvão and Ricarte (2020), and Okoli (2015), who recommend starting with the delimitation of the objective and planning of the protocol, followed by the stages of practical selection, search, data extraction, quality assessment, synthesis of studies and writing of the review, which are detailed below.

The Process of Developing the Systematic Literature Review

The SLR consists of a secondary research modality, carried out based on a guiding question, which aims to create a file that includes a synthesis of the knowledge previously published in the study being developed, being relevant to summarize evidence, identify gaps, present a general overview of a given theme and favor the development of new research that can contribute to the advancement of the field (Campos et al., 2023). This SLR is, therefore, an excerpt from a doctoral research in Science Teaching and Mathematics Education, which deals with ISE.

As a way to identify how the discussions about Intercultural Science Education are going at the national and international levels, we established the following databases as search sources: Scopus (https://www.scopus.com), Web of Science (https://clarivate.com/products), Dialnet (https://dialnet.unirioja.es/), and the Network of Scientific Journals

of Latin America and the Caribbean, Spain and Portugal (Redalyc) (https://redalyc.org/). After defining the databases, we searched for descriptors that contemplated ISE in science teaching in traditional communities. To this end, we resorted to reading some articles published on the object of research, focusing on the identification of keywords, as well as synonyms representing the theme under investigation. Subsequently, we cross-referenced the descriptors from the combination of Boolean operators and special characters. The use of the Boolean operator OR corresponds to the union, so we used it to contemplate the synonyms of concepts. The AND operator, on the other hand, corresponds to the intersection; therefore, it restricts the search for studies that involve Interculturality in science teaching.

We established the following descriptors: science teaching, science education, Intercultural, and Interculturality. With the definition of the descriptors, we then delimited as inclusion criteria the type of study and content, including primary and secondary studies, that is, empirical and theoretical studies, as long as they were related to Interculturality in the area of science teaching. We also considered the quality of the material, the publication vehicles, the language, and the year. Consequently, we selected papers published between 2014 and 2024, in full, in Portuguese, Spanish, or English, which were peer-reviewed and made available in the Scopus, Web of Science, Dialnet, and Redalyc databases. We performed the search on December 5, 2024, crossing ("Intercultural" OR "Interculturality") AND ("science teaching" OR "science education") and obtained 1,487 studies; after refining the search considering the criteria mentioned above, this number reduced to 486 studies, of which 45 are from Web Of Science, 45 from Dialnet, 51 from Scopus, and 345 from Redalyc (Figure 1).

Figure 1

Search results performed on Web Of Science, Dialnet, Scopus, and Redalyc

Database	Number of articles	Selected after refinement
Web Of Science	881	45
Dialnet	54	45
Scopus	94	51
Redalyc	458	345
Total	**1,487**	**486**

With the refinement of the search, we excluded studies published in a year earlier than 2014, namely: 1992, 1993, 1997, 1999, 2001, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, and 2013. In addition, we did not select editorials, books, or book chapters, proceedings of events, or interviews. We also did not analyze studies published in languages other than English, Spanish, or Portuguese, such as those written in Bulgarian (n=1), French (n=2), and Russian (n=1).

In this context, of the 486 studies selected after the search refinement stage, we cross-referenced them in an Excel spreadsheet and found that 36 were repeated, leaving 450 articles for analysis. Then, we read the titles, abstracts, and keywords. From this preliminary reading, it was possible to determine that 369 studies would be excluded, considering that 4 were not available for full reading and 365 were not related to the teaching of science, such as studies focused on computer science, mathematics, medical sciences, English language, bilingualism, and sociology, for example. Therefore, we selected 81 articles for full-text reading.

With the 81 studies selected, we read the full text in order to produce information that would help answer the guiding question of the SLR. Then, we organized the information in an electronic spreadsheet, containing the following information: year of publication, names of the authors, title of the work, abstract and keywords, country where the study was developed, language, intervention performed, participants, level of education, and synthesis of the main ideas. In parallel, we conducted a quality assessment, considering the coherence of the study, the theoretical framework, methodological approach, results, and final considerations, which resulted in the exclusion of 31 studies, thus composing this review of 50 articles published between the years 2014 and 2024. From the data we produced and systematized in electronic spreadsheets, we synthesized the findings, making an interpretative analysis, establishing relationships of combinations and comparisons between the studies, based on the theoretical-methodological guidelines of Campos et al. (2023), Galvão and Ricarte (2020), and Okoli (2019).

Results and Discussion

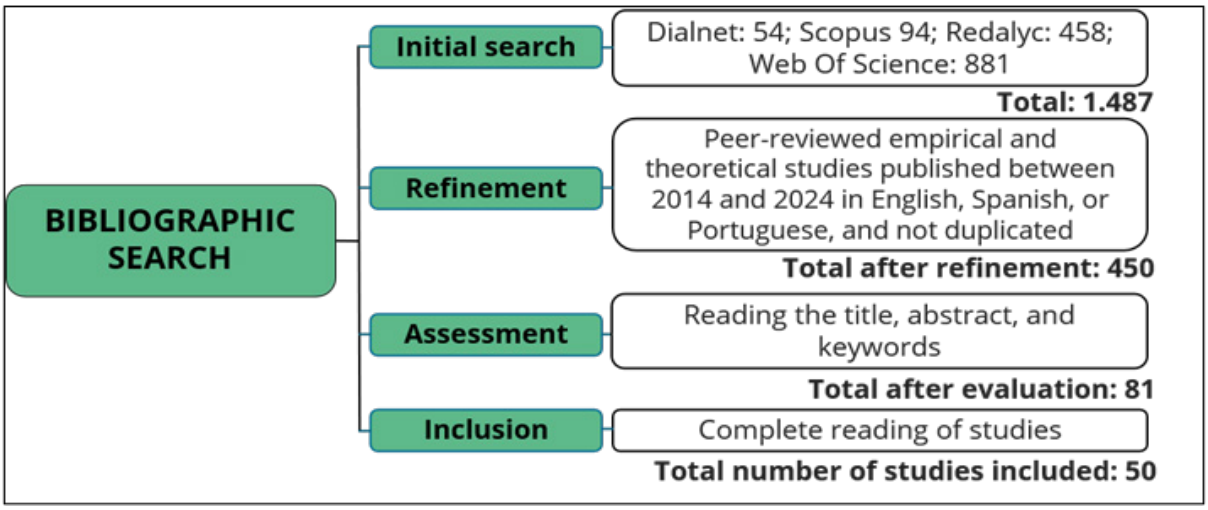
Next, we discuss the main results we obtained, starting with the characterization of the studies, followed by a discussion of the relationship between traditional knowledge and scientific knowledge, characterizations of Intercultural Science Education, and strategies for promoting ISE. Subsequently, we present challenges and proposals for overcoming, as well as some considerations about SLR.

Characterization of the Studies Included in the Review

The sociocultural diversity present in different countries can justify the large number of studies that we found in our investigation, which reveals the interest of researchers in recognizing, valuing, and amplifying the traditional knowledge of the holders of this diversity. We systematized the expressiveness of the search results, followed by the paths we followed for the development of this review (Figure 2).

Figure 2

Overview of the literature search process in the databases



Although the production of the field of ISE may seem well developed and abundant, we believe that it is on the rise and still lacks new perspectives, considering the historical process of silencing and delegitimizing the knowledge of invisible groups. In view of this, investigations in this field are welcome if we wish to expand the possibilities to increase the pedagogical practices of teachers in science teaching, so that they can consider traditional knowledge in their classes.

Of the 50 studies we analyzed, which were published between 2014 and 2024, we found that they were mostly developed in the Global South. We are considering here as the South and consequently Global North not necessarily the geographical location, but rather the oppressed and oppressive poles, that is, the South as a space that has undergone oppression, especially as a result of capitalism, patriarchy and colonialism, as well as the one that has developed resistance to these oppressions, while the North corresponds to spaces in the Northern and Southern Hemispheres in which oppression of the Global South has been established and still establishes (Guerra & Moura, 2022).

Considering that this review includes both primary (empirical, n=34) and secondary (theoretical, n=16) studies, at the international level, we defined the location based on the country. When it came to empirical studies, we considered the country where the study was conducted; in the case of theoretical studies, we considered the country in which the institutions to which the first author is affiliated are located. Thus, we identified that 92% (n=46) of the studies that make up this review are by researchers from Latin America, with Brazil being the country that stands out the most, with 54% (n=27) of the studies analyzed, of which 2 were developed in partnership with other countries: Colombia and Portugal. In addition to Brazil, we found studies from Colombia (n=9), Argentina (n=4), Chile (n=3), and Mexico (n=3). Although less expressive (8%, n=4), we found studies from England (n=1); the United States (n=1); Germany, which was developed in partnership with Cyprus, Malta, the Netherlands, Spain, and Turkey (n=1), and in Australia, in partnership with Malawi (n=1).

We consider that this analysis, although superficial, indicates where the discussion around the ISE has taken place, which may be related to the diversity present in these countries. We found studies conducted, for example, on aspects related to indigenous peoples (n=12), farmers (n=5), artisanal fishermen (n=4) and *quilombolas* (n=1), within the scope of the regular education, Youth and Adult Education, and Rural Education, at all levels and stages of education, with the exception of early childhood education. Among the participating public, in addition to representatives of traditional communities, we highlight students, undergraduates, basic education teachers and university students, which demonstrates that the field has been explored at the most diverse levels and stages of education, with a focus on the initial and continuing training of teachers.

In general, we found, from the studies we included, that the ISE is developed from the perspective of the studies of Boaventura de Sousa Santos (n=14), Paulo Freire (n=8), William W. Cobern and Cathleen C. Loving (n=8), Glen S. Aikenhead (n=8), Lev Vygotsky (n=7), William W. Cobern (n=7), Vera Candau (n=6), Brown, Collins and Duguid (n=4), Catherine Walsh (n=4), Enrique Leff (n=2), and Glen S. Aikenhead and Masakata Ogawa (n=2), who are situated in different theoretical perspectives, such as Symbolic Interactionism, Situated Cognition, Contextual Constructivism and Epistemological Pluralism.

In addition, we identified that Interculturality takes on different perspectives. By way of illustration, while in the studies developed in Argentina, Brazil, Colombia and Mexico, for example, the ISE focuses on the knowledge of traditional communities, especially indigenous peoples; in countries where the human migration flow is a reality, the ISE assumes a bilingual and integration perspective, as is the case of some studies developed in Chile and Germany, for instance.

Although there is a distinction in the approach, the studies share the common objective of developing sensitivity to cultural diversity, that is, the recognition, appreciation, and respect for cultures. To this end, the authors explored the cultural aspect in science teaching by strengthening the relationship with people from traditional communities, producing didactic materials, and listening to the conceptions of students and teachers. Such actions are relevant for envisioning promising paths in the teaching of science that are sensitive to diversity.

From this perspective, we will present below a figure containing the list of studies that we included in this review, as well as the main contribution, which we highlight as theoretical and practical, including in the latter strategies used by the authors to develop ISE (Figure 3). We emphasize that, although we have attributed one of the two contributions to each study, this does not imply that a theoretical study does not contribute to the reflection on strategies, nor that a study of practical contribution does not bring theoretical contributions.

Figure 3

List of studies included with indicative contributions to the review

Authorship	Year	Main contribution	Place of study
Alvim	2023	*Theoretical* — Importance of valuing epistemic diversity	Brazil
Amorim & Baptista	2020	*Practical (Conceptions)* — Proposal for diversity-sensitive curricular changes	Brazil
Bagdonas & Silva Neto	2023	*Theoretical* — Importance of valuing epistemic diversity	Brazil
Baptist	2018	*Practical (CCT)* — Creation of Contextual Cognition Tables	Brazil
Baptist	2015	*Practical (Ethnobiology)* — Teacher training sensitive to diversity	Brazil
Baptista & Araujo	2019	*Practical (Ethnobiology)* — Teacher training sensitive to diversity	Brazil
Baptista & Molina-Andrade	2021	*Practical (Conceptions)* — Science teaching in traditional communities	Brazil
Baptista et al.	2023	*Practical (Conceptions)* — Intercultural Dialogue in Education in Rural Areas	Brazil
Bascopé & Velarde	2016	*Practical (Teaching materials)* — Creation of materials that bring traditional knowledge closer to the school curriculum	Chile
Bejarano et al.	2014	*Practical (Conceptions)* — Image cards for interviewing students	Brazil
Bonan et al.	2021	*Practical (Bridges)* — Common theme between traditional knowledge and scientific knowledge	Argentina
Castillo	2021	*Practical (Conceptions)* — Linking school to cultural and environmental context	Colombia
Chadwick & Bonan	2018	*Practical (Bridges)* — Common theme between traditional knowledge and scientific knowledge	Argentina
Contreras & Soto	2023	*Practical (Conceptions)* — Science Education in the context of cultural diversity	Chile
Crepalde & Aguiar Júnior	2014	*Practical (Bridges)* — Common theme between traditional knowledge and scientific knowledge	Brazil
El-Hani	2022	*Theoretical* — Theoretical-philosophical bases for Intercultural Science Education	Brazil
El-Hani & Ludwig	2024	*Theoretical* — Theoretical-philosophical bases for Intercultural Science Education	Brazil
Flores-Silva et al.	2020	*Practical (Didactic Resources)* — Textbook Analysis	Mexico
Franco & Ramírez	2016	*Practical (Teaching materials)* — Creation of materials that bring traditional knowledge closer to the school curriculum	Mexico
Gandolfi	2023	*Theoretical* — Science Education and Interculturality	England

Figure 3

List of studies included with indicative contributions to the review (continuation)

Authorship	Year	Main contribution	Place of study
Ganesan & Morales	2024	*Theoretical* — Intercultural competence among students in multilingual classrooms	United States
Gondwe & Longnecker	2015	*Practical (Bridges)* — Construction of maps to create approximations between scientific and cultural domains	Australia
Guerra & Moura	2022	*Theoretical* — Importance of valuing epistemic diversity	Brazil
Hernández-Barbosa	2018	*Practical (Bridges)* — Common theme between traditional knowledge and scientific knowledge	Colombia
Ibarra et al.	2022	*Practical (Bridges)* — Biocultural memory and intergenerational dialogue	Chile
Kato et al.	2023	*Theoretical* — Implication of scientific knowledge in the production of contemporary society	Brazil
Manetta & Baptista	2022	*Practical (Teaching materials)* — Intercultural Environmental Education	Brazil
Martins et al.	2021	*Practical (Course)* — Initial training of teachers sensitive to diversity	Brazil
Melo-Brito	2019	*Practical (Bridges)* — Common theme between traditional knowledge and scientific knowledge	Colombia
Melo-Brito	2017	*Theoretical* — Model of Bridges between traditional and scientific knowledge systems	Colombia
Monteiro & Zuliani	2020	*Practical (Conceptions)* — Science teaching in indigenous schools	Brazil
Orjuela-Osorio	2023	*Practical (Conceptions)* — Teachers' performance in an indigenous context	Colombia
Páez-Rincón & Reyes-Roncancio	2020	*Practical (Bridges)* — Common theme between traditional knowledge and scientific knowledge	Colombia
Peñaloza et al.	2023	*Theoretical* — Potential of Science Education to engage with cultural diversity through the lens of Freire's concept of dialogue	Brazil and Colombia
Pérgola et al.	2021	*Practical (Teaching materials)* — Creation of materials that bring traditional knowledge closer to the school curriculum	Argentina
Rédua & Kato	2020	*Practical (Course)* — Workshops with problem situations for teacher training	Brazil
Riveroll	2021	*Theoretical* — Theses for Interculturality	Mexico
Robles-Piñeros & Baptista	2022	*Practical (Ethnobiology)* — Valuing the traditional knowledge of student farmers in Intercultural Education	Brazil

Figure 3

List of studies included with indicative contributions to the review (continuation)

Authorship	Year	Main contribution	Place of study
Robles-Piñeros et al.	2023	*Practical (Conceptions)* — Profile of teachers sensitive to cultural diversity	Brazil
Robles-Piñeros et al.	2020	*Theoretical* — Approximation of traditional farmers' knowledge to scientific knowledge	Brazil
Rodrigues & Leite	2020	*Theoretical* — Indicates axes or lines of action that can guide Intercultural practices	Brazil
Rodriguez	2021	*Theoretical* — Challenges of teacher training to relate science and culture	Colombia
Santos et al.	2021	*Practical (CCT)* — Approximation between traditional agricultural and scientific knowledge in botany classes	Brazil
Silva & Ramos	2019	*Practical (Ethnobiology)* — Traditional knowledge in education	Brazil
Sorge et al.	2023	*Practical (Course)* — Interculturality and Migration	Germany
Tovar-Gálvez	2023	*Practical (Bridges)* — Epistemological Bridge Model	Colombia
Uribe-Pérez	2020	*Practical (Conceptions)* — Initial training on ISE	Colombia
Valadares & Silveira Júnior	2020	*Practical (Bridges)* — Influence of astronomy on agriculture using a simulated jury in initial training	Brazil
Vargas et al.	2014	*Practical (Teaching materials)* — Importance of reforming curricula with the inclusion of Ethnobiology	Brazil
Vergara & Albanese	2022	*Practical (Conceptions)* — Importance of conceptions for Interculturality	Argentina

We will begin presenting the results with the theoretical contributions, and then present the practical ones, with regard to the systematization and discussion of strategies that can inspire teaching practices sensitive to cultural diversity. Before doing so, we would like to highlight that, as for the studies excluded after full-text reading, they mentioned interculturality. However, in some cases, there was no theoretical deepening of the concepts we were looking for (n=11), and the focus of Science Education was secondary to the specificities of indigenous school education (n=4) and decoloniality (n=4), as well as collaborative work (n=1), the nature of science (n=2), education for sustainable development (n=1), multiculturalism (n=1), the human-nature relationship (n=1), pedagogical residency (n=1), religion (n=1), rural education (n=1), contextualization (n=1), the university-school relationship (n=1) and music (n=1).

Although we excluded them, these studies presented aspects related to the importance of developing sensitivity to cultural diversity. However, these perspectives are contemplated in different proportions in the studies we included, and therefore, the exclusion of some studies did not affect the content of this review.

Traditional Knowledge and Scientific Knowledge

Static, ancient knowledge, history and religion *versus* experiment, intelligence, genius, lab coat, advanced and valid knowledge. These were concepts identified by Gondwe and Longnecker (2015) when they asked students to define culture and science. We easily recognize which words belong to which field, as a result of the distance and hierarchy that these two knowledge systems have had over time.

Before presenting the authors' discussions about traditional and scientific knowledge systems, we want to make it clear, initially, what a knowledge system is, considering that ISE presupposes the approximation of different systems. In view of this, in this section, we present what a knowledge system is, as well as the discussions around the terms traditional knowledge and scientific knowledge.

Regarding the concept of knowledge systems, we rely on El-Hani and Ludwig (2024, p. 3), who define them as those that:

> show a determinate degree of internal and practical coherence, derived from the way they develop along generations of agents dealing with situations embedded in the socio-environmental circumstances in which they carry out their cognitive and practical actions. Knowledge systems contain claims about the world showing content related to such situations and actions (not only negative claims against what other knowledge systems state), show a degree of internal coherence, are based on the practices of a community, and show pragmatic value in relation to situations influencing their development.

This definition allows traditional knowledge and scientific knowledge to be recognized as knowledge systems, which, in ISE, are seen as cultures that meet. In this context, scientific knowledge is characterized as culture, which stems from the fact that academic scientists share and interact socially with a system of well-defined meanings and symbols (Crepalde & Aguiar Júnior, 2014).

Regarding the representations of these knowledge systems, Gondwe and Longnecker (2015) state that these are domains of provisional consensus, in which the definition is not consensual. From the studies analyzed, we found that the systems represented by traditional knowledge and scientific knowledge assume different terms. While the first system can be indicated by local knowledge, traditional ecological knowledge, traditional knowledge, ancestral knowledge, cultural knowledge, the second can be described as school scientific knowledge, scientific knowledge, Western science, academic ecological knowledge, modern science, among others.

Regardless of the term used to refer to these systems, we found that the authors present a critical analysis of the relationship between traditional knowledge and scientific knowledge, highlighting the historical hierarchy between the two, due to colonization and, more recently, globalization (El-Hani & Ludwig, 2024). The authors argue that both are legitimate knowledge systems, with their own validity, and that ISE can create spaces for dialogue between them, recognizing and valuing them in order to develop a

culturally sensitive education. As for scientific knowledge, El-Hani (2022) assumes the terms academic science, academic scientific knowledge, and its derivatives to refer to scientific knowledge, which is developed and certified in academic institutions, research centers, and laboratories, for example.

Studies reveal that science is seen as one among other ways of explaining reality and not as the best form of knowledge among the others that exist (Crepalde & Aguiar Júnior, 2014; Guerra & Moura, 2022; Melo-Brito, 2017). It is a fact that science is relevant to students, but if we want Science Education to provide benefits to communities, it is necessary to develop science teaching that does not harm students' relationships with their cultural origins and contributes to the creation of spaces for possible dialogues between scientific knowledge and local knowledge (El-Hani & Ludwig, 2024). It is important to consider that, although students are still learning school content, they also hold at least part of the knowledge of their communities (Bejarano et al., 2014; Martins et al., 2021). This knowledge is approached by several authors as a way of interpreting the reality that emerges from the interactions between human beings and the environment, transmitted over generations and learned through practice and observation (Bascopé & Velarde, 2016; Hernández-Barbosa, 2018; Silva & Ramos, 2019).

One of the features of knowledge coming from traditional communities is demarcated by the deep relationship that people maintain with nature, as their survival depends on it (Peñaloza et al., 2023). The knowledge produced by these communities not only contributes to the existence but also to the preservation of natural, cultural, and historical heritage (Martins et al., 2021). However, their knowledge is often marginalized, being judged as poorly elaborated or superstitious in relation to scientific knowledge (Riveroll, 2021).

This aspect raises an alert to think about actions that can make the knowledge coming from these communities visible in the school space (Páez-Rincón & Reyes-Roncancio, 2020), especially those who are in a situation of social vulnerability, who are mostly stigmatized as deficient (Riveroll, 2021).

From the perspective of the aforementioned authors, we found that the relationship between the traditional and scientific knowledge systems is marked by historical tensions that result in the delegitimization of identities and knowledge, although this relationship has an enriching potential when adopting a perspective of Intercultural Scientific Education. ISE proposes a dialogical approach, in which both systems are recognized and valued in their specificities and potentialities, which allows the exploration of different ways of understanding the world, promoting culturally sensitive teaching.

Intercultural Science Education as a Space for Dialogue

The term Interculturality has its origin in Europe, initially developed as an approach to promote cultural exchange between immigrants and natives (Europeans), and later introduced into education, intending to promote cultural coexistence in

multiculturally diverse societies, especially in response to increased immigration, as a way of recognizing and learning to deal with differences (Robles-Piñeros et al., 2023). This is a reality that includes not only countries in Europe (Sorge et al., 2023), but also countries such as Australia (Gondwe & Longnecker, 2015), Colombia (Uribe-Pérez, 2020), Chile (Contreras & Soto, 2023), and Mexico (Franco & Ramírez, 2016). For this reason, its application has expanded globally, with different meanings in different contexts, configuring a permanent conceptual construction, as Vergara and Albanese (2022) acknowledge.

In Latin America, the concept of Interculturality has evolved in a critical direction, recognizing historically silenced social groups (Uribe-Pérez, 2020). Especially in the literature of Brazil and Colombia, Interculturality values the dialogue between traditional knowledge and scientific knowledge, reinforcing the importance of Ethnobiology, history, and philosophy of science in this process (Robles-Piñeros et al., 2023).

In addition to the consideration of diversity in the educational context, other factors that influence the development of Interculturality in Latin American and Caribbean countries are the neoliberal policies that affect them (Kato et al., 2023; Riveroll, 2021), reinforcing a model of capitalist economic bias (Baptista & Molina-Andrade, 2021). Such policies have aroused in researchers the rejection of any attempt to homogenize culture, considering that these countries are biologically, linguistically, ethnically and culturally diverse (Vargas et al., 2014) as a result of their native groups, which is common in countries such as Brazil, Mexico, Colombia, Peru, Chile, Canada, Australia and African countries (Monteiro & Zuliani, 2020).

In the educational context, Interculturality can contribute to the construction of a more just, democratic, and plural society (Pérgola et al., 2021). In addition, it is developed from the perspective of dialogue between traditional and scientific knowledge systems, an approach that is of interest to us in this study. Therefore, it seeks to respect, recognize, and value cultures and different knowledge systems, promoting dialogue and valuing traditional knowledge, while opposing teaching practices that repeat knowledge year after year and knowledge that is restricted to the school environment (Vargas et al., 2014). To this end, it is based on three central aspects: the intercultural attitude with a pragmatist pluralist bias, the approach of partial convergences in three domains (epistemological, ontological, and axiological), and intercultural translation as a producer of meaning (El-Hani & Ludwig, 2024). These three aspects will be discussed later, but first, it is important to clarify what Intercultural Science Education is.

Throughout the construction of this review, we found authors who bring their own conceptualizations of what they understand and defend as ISE, which converge in some aspects, such as the fact that it starts from sensitivity to cultural diversity (Castillo, 2021; Peñaloza et al., 2023; Riveroll, 2021; Uribe-Pérez, 2020; Vergara & Albanese, 2022).

In addition to the recognition of cultural diversity, another common point in the definitions, mentioned by some works, is the type of relationship that is established, using the expressions encounter, interrelation, exchange or integration between cultures

and knowledge (Amorim & Baptista, 2020; Chadwick & Bonan, 2018), communication between the culture of science and those of students (Baptista & Araújo, 2019; Páez-Rincón & Reyes-Roncancio, 2020), articulation or dialogue between the knowledge of traditional communities and scientific knowledge (Kato et al., 2023) and dialogue between knowledge systems or knowledges (Robles-Piñeros et al., 2020; Uribe-Pérez, 2020).

Although the idea of contact and dialogue between cultures, traditional knowledge, and scientific knowledge seems to be peaceful, we identified in the works that when different knowledge systems are related, at least three situations can occur: convergence, divergence, and negotiation. Thus, it is not the objective of ISE that in the established relationship there is comparison as a way of replacing, imposing, or inducing a (traditional) knowledge system to value and accept another (scientific) or to make students move towards one of these domains permanently (Santos et al., 2021). Instead, it is necessary to recognize similarities and differences, so that students can understand that these are two ways of knowing the world (Robles-Piñeros & Baptista, 2022).

From this perspective, the authors seem to agree on the fact that conflicts can occur as a result of differences in this relationship (Uribe-Pérez, 2020). These divergences are important for students to be able to expand the search for respect, tolerance, and peaceful coexistence based on negotiations of meanings and the feasibility of the applicability of different knowledge systems in different cultural contexts (Amorim & Baptista, 2020; Flores-Silva et al., 2020). Thus, ISE seeks points that connect different knowledge systems, but reaffirms the difference (Uribe-Pérez, 2020).

Still dealing with aspects associated with ISE, we note a tendency to criticality among some authors, who propose its development as a way of assuming a discourse of scientific knowledge as one among several knowledge-producing cultures (Alvim, 2023; Gandolfi, 2023; Kato et al., 2023). Such recognition aims to enable students to understand that scientific activity varies according to different cultures and moments in history, as well as to understand how other cultures have developed their own knowledge (Contreras & Soto, 2023).

In addition, the ISE is seen as a decolonial project, which recognizes the plurality that makes up Latin America. From this perspective, the relations of power and/or domination between knowledge systems are discussed, focusing on valuing aspects of ancestry and the struggle of peoples who, ethnically, culturally, and, above all, epistemically, were silenced, made invisible, discriminated against, or excluded by coloniality (Kato et al., 2023). Therefore, it seeks to incorporate the cultural heritage of traditional communities (identity and collective memory of these peoples) in the school environment as a form of resistance to standardized, hegemonic, and homogenizing educational models, in order to decolonize epistemic, philosophical, and pedagogical aspects (Uribe-Pérez, 2020).

Another aspect often mentioned by the authors, and that is closely linked to the characterization of the ISE, concerns its contributions, which go beyond the pedagogical aspect. The authors highlight the possibility of broadening students' worldviews and fostering reflection on their own identities (Baptista, 2015; Ganesan & Morales, 2024). In addition, they report positive effects on the development of autonomy in decision-making in the face of situated contexts, which usually requires the choice of which knowledge is most appropriate (Riveroll, 2021). Páez-Rincón and Reyes-Roncancio (2020), in turn, report that students can have a more authentic approach to scientific knowledge, which, in the case of biological knowledge, can materialize from the approximation and understanding of the phenomena of nature in the environment in which they live.

The authors also report as contributions the potential for meaningful learning by students who experience ISE-based approaches (Chadwick & Bonan, 2018). These approaches have also led to an increase in interaction between students, questions, and participation in classes, enabling the exposure of different ideas (Baptista, 2015). In addition, Bascopé and Velarde (2016) highlight the integration and commitment of families in the educational sphere, considering them as producers of knowledge that can be articulated with teaching.

It is possible, therefore, to think of a science that is beyond that present in the curricula and framed in opposition to non-scientific knowledge (Gandolfi, 2023). To this end, Robles-Piñeros and Baptista (2022) reinforce the importance of knowing the school environment, the resident population, and its dynamics, in order to enable non-imposing teaching.

Based on the considerations of the aforementioned authors, we identified what seems to be a consensus that ISE can be defined as an attitude sensitive to cultural diversity, that is, one that recognizes, values, and respects diverse and legitimate ways of producing knowledge beyond the scientific. It is characterized as a space between knowledge systems in which there is a relationship of encounter or exchange between cultures (students' culture and scientific culture). It proposes the approximation and dialogue between invisible knowledge and scientific knowledge, considering the relations of similarity and difference. Such consideration does not presuppose the comparison or establishment of hierarchy, in which one system must be supplanted in the light of the other, but that conflicts and tensions can arise, and from these, mutual learning can occur.

Once the concept and characteristics of the ISE have been discussed, we will now focus on three of its central aspects, starting with the intercultural attitude with a pragmatist pluralist bias, passing through the model of partial convergences and intercultural translation.

From Universalism to Pragmatic Pluralism

Different authors express criticism of scientism and epistemic colonialism, phenomena related since scientism originated in medieval Europe and spread through colonization and imposed modern Western science as the only qualified system for the construction of legitimate and valuable knowledge for the life and development of societies (Vargas et al., 2014). This process resulted in an "epistemicide" marked by the devaluation of the knowledge of colonized peoples (Vergara & Albanese, 2022).

However, this critique is not a rejection of scientific knowledge, but rather a contestation of its exclusive position as a source of truth (Vargas et al., 2014). Expanding the idea of science by opposing its claim to universal truth, as well as advocating for intercultural dialogue among different knowledge systems, does not mean opposing the legacy of science, relativizing it, or denying it (Guerra & Moura, 2022; Kato et al., 2023). It is not an incentive to affiliation with denialist ideas and discourses, discrediting or devaluing science (Alvim, 2023; Vergara & Albanese, 2022). Nor can it be interpreted as a way of affirming that any information is legitimate without considering its epistemic production process (Bagdonas & Silva Neto, 2023; Riveroll, 2021). In fact, what the authors defend is a pragmatist pluralist vision, where different knowledge systems are valued and can dialogue with each other.

As a result of the post-truth scenario, in which social acceptance of false information and the uncritical rejection of widely accepted scientific facts are growing, Riveroll (2021) points out that the pluralist perspective is absent or weakened as part of the public image of science that is disseminated, thus increasing the risks associated with extreme relativism. For this reason, it is not proposed to defend ideologies that do not qualify as knowledge systems, and therefore should not be participants in classroom dialogues, except for critical purposes, as in the case of pseudosciences or denialisms that raise different questions about the relationship between knowledge systems (El-Hani & Ludwig, 2024). Such ideologies "lack sufficient coherence, piling up claims that contradict each other, do not show pragmatic value, and/or are mostly comprised of negative claims to what scientific views state" (El-Hani & Ludwig, 2024, p. 3). It is important to consider, therefore, that "regardless of its epistemic and social shortfalls, science still is our greatest instrument against pseudoscientists, charlatans, fundamentalists, cynic politicians and moralists", and therefore, it is important to appreciate and value its epistemological, ontological, and philosophical characteristics (Kato et al., 2023, p. 221).

In addition to not implying attachment to denialist discourses, assuming an intercultural stance also does not mean that we should limit ourselves to community-based objectives or that the interest and relevance for members of traditional communities to know scientific ideas should not be considered (El-Hani & Ludwig, 2024). These authors also point out that it is not a matter of delimiting equal times and emphasis on different knowledge systems, where it is assumed that one is understood to the detriment of the other. In addition, it should not be developed merely as a way to facilitate the learning of scientific concepts.

Assuming an intercultural stance means, in fact, a broad, pluralistic border thinking, when reflecting on the constitution of science as the only valid form of knowledge and the possibility of relating it to the traditional system. This can occur through the recognition of the existence and validity of traditional knowledge as legitimate forms of knowledge, making them visible for the establishment of a dialogue of mutual enrichment (Alvim, 2023; Guerra & Moura, 2022). It is more about recognizing, valuing, and respecting both the cultures that are unique to where students originate and the scientific culture, and, at the same time, developing the ability to cross boundaries between these cultures and choose the one that best suits the required situations (Riveroll, 2021).

The rapprochement between cultures must be aligned with the importance of scientific ideas, especially regarding the role they can play in relation to the goals and aspirations of communities (Vargas et al., 2014). In this way, it is hoped that Intercultural Dialogue will continue to communicate science, but in a way that promotes spaces for the recognition of traditional knowledge as legitimate ways of interpreting reality, establishing negotiations on how they relate to scientific explanations, whether in terms of similarities and/or differences, meanings, and application (Baptista & Molina-Andrade, 2021). The construction of new meanings is expected, but without delegitimizing knowledge according to its cultural origin, which was built as part of identity and belonging to a community (Orjuela-Osorio, 2023).

From this point of view, assuming an intercultural attitude demands the search for an intermediate path to the idea of relativism that is committed to total incommensurability, by recognizing different but equally valid systems of knowledge (El-Hani, 2022). For El-Hani and Ludwig (2024, p.13) there is a way for "distinguish between better or worse knowledge choices in the face of objective states of affairs", another form of "relativism", which qualifies the idea of incommensurability and aligns itself with a pragmatist pluralist stance. Therefore, knowledge systems have different forms of validation, which can be compared and evaluated based on situated and contextual criteria, which rules out the character of total incommensurability (El-Hani & Ludwig, 2024). For these authors, in general, it is not interesting to compare different knowledge systems, unless this comparison is required punctually in a situational context in which the individual must choose one of the systems to respond to the situation.

It is important to emphasize that the consequences should not be confused with the idea of "practical utility" or "application". In addition, it is important to think about the consequences in terms of the type of intervention in the world that they provide or help, and also what they prevent (El-Hani & Ludwig, 2024). We do not deepen the debate about relativism and universalism, as well as pragmatism, as an in-depth discussion is in the work of El-Hani (2022) and El-Hani and Ludwig (2024).

Adhering to the pragmatist pluralist stance in the ISE can contribute to the active avoidance of overly optimistic, folkloric, and caricatured practices. We hope that practices will be established with a critical bias in the opposite direction to scientific denialism and epistemic and cultural relativism. Therefore, we must be careful that educational spaces do not reinforce stereotypes, folklorize culture, and erase differences (Gondwe & Longnecker, 2015). In other words, it is not a matter of abandoning one form

of knowledge to the detriment of another, but of moving between them in a productive way (Crepalde & Aguiar Júnior, 2014). In short, we identified that ISE requires an attitude with a pragmatist pluralist bias, which consists of recognizing and valuing the multiple ways of producing knowledge, whether scientific or non-scientific, and, based on the consequences, choosing the knowledge system that best meets the given situation.

Bridges, the Model of Partial Convergences and Intercultural Translation

Although Intercultural Dialogue can provide us with contributions, it is important not to ignore its limitations and pitfalls (El-Hani & Ludwig, 2024). According to Robles-Piñeros et al. (2020), recognizing traditional knowledges as legitimate ways of interpreting reality creates complex methodological challenges, as a result of the tensions that can be caused by divergences with scientific knowledge.

Among the limitations of proposing this approximation or coexistence between knowledge systems, we highlight the fact that it indirectly deprives the differences that are unique to each system and reproduces a certain hierarchy between communities and scientists, considering that the holders of traditional knowledge are often submitted to the approval of scientific knowledge according to academic methodological and epistemological criteria (Vargas et al., 2014). This means that traditional knowledge is treated as a simple toolbox "that may or may not be used conveniently while maintaining an overall narrative of epistemic and ontological superiority of Science" (Robles-Piñeros et al., 2020, p. 7). From this perspective, not recognizing the possible limitations when trying to bring knowledge systems closer together, promoting Intercultural Dialogue and spaces for co-production, for example, can materialize as an action that reproduces a utilitarian or neocolonial attitude, a situation in which differences are ignored (El-Hani & Ludwig, 2024).

From this point of view, the authors recognize that it is important to create bridges between traditional and scientific knowledge systems (Bonan et al., 2021; Chadwick & Bonan, 2018; Páez-Rincón & Reyes-Roncancio, 2020). This metaphor is associated with the fact that bridges allow distant places to communicate through a shared space (Tovar-Gálvez, 2023). In ISE, this refers to the establishment of common themes, which can promote intersections, exchanges, and the emergence of relationships between two epistemologically different positions (Melo-Brito, 2017). By acting as a transitional space, bridges imply a dialogue that promotes exchange (Melo-Brito, 2017), which requires the consideration that knowledge systems are at the same level, that is, there is no imposition or supremacy of one over the other (Hernández-Barbosa, 2018).

Despite having contact with different knowledge systems, the bridge does not propose that students replace their knowledge with scientific knowledge, but rather that, while learning science, they maintain the epistemology of their communities, as well as their identities and epistemological commitments (Tovar-Gálvez, 2023). Consequently, in the proposition of Intercultural Dialogue, it is important to consider that the epistemologies have similarities, which favor the exchange to take place. However, it is also important to consider independence, that is, that differences are respected in this dialogue process (Tovar-Gálvez, 2023). It is from the consideration of these differences

that the model of partial convergences emerges. El-Hani and Ludwig (2024) recognize that it is necessary to create bridges, that is, to seek convergences that facilitate dialogue, but differences cannot be abandoned, so that the approximation between knowledge systems must be accompanied by an interepistemic and interontological dialogue, in order to recognize and understand the divergences that need to be negotiated in culturally sensitive Science Education processes.

El-Hani (2022) avoids using the English translation "partial overlaps", as he believes that the term "overlap" has the connotation of one system of knowledge being placed in a position of predominance in relation to the other, which contradicts the concept itself. For this reason, he uses the term "convergence", which does not suggest this same connotation. Thus, we also adopted the term partial convergences, to refer to the model that allows us to guide negotiation processes between knowledge systems in order to obtain a common ground that promotes dialogue, while emphasizing differences.

From this approach, it is possible to analyze the relations of approximation (convergences) and distancing (divergence or partiality) established between knowledge systems in the ontological, epistemological, and value dimensions (El-Hani, 2022). While the analysis of convergences can highlight what is common and that contributes to mutual collaboration and learning and favors intercultural translation and the co-production of knowledge, the analysis of distancing can, on the other hand, awaken the reflection of those involved in the relationship regarding the normative and political positions they assume when different knowledge systems are brought together (Robles-Piñeros et al., 2020).

Therefore, when seeking to identify partial convergences, it is important to consider that ontological, epistemological, and axiological commitments co-determine each other, i.e., the way we understand reality (ontology) influences the way we construct and validate knowledge (epistemology), which, in turn, influences what we assume exists and how we categorize it (El-Hani & Ludwig, 2024). Thus, we need to recognize that different knowledge systems have distinct ontological, epistemological, and axiological commitments, given their contexts of production. Consequently, identifying ontological convergences "would mean to translate from one culture or knowledge system to another with no indetermination or ontological relativity", that is, it does not consist of finding a direct translation, but interpreting some convergence (El-Hani & Ludwig, 2024, p. 19). Through intercultural translation, shared cultural spaces can have their reach expanded, not restricting themselves to recognizing otherness, but, above all, engaging with it (El-Hani, 2022).

In the educational field, Robles-Piñeros et al. (2020) state that non-hierarchical exchanges between knowledge systems rarely occur, and associate this hierarchy with heterogeneous factors specific to the school and to the fact that traditional knowledge is used only with what converges with the scientific. Instead of seeking a total fusion, what is proposed is the search for encounters, but do not underestimate the uniqueness of each knowledge system.

To this end, we must deprive ourselves, according to El-Hani and Ludwig (2024, p. 27), of being "overly optimistic integration", that is, disregarding differences, as well as avoiding being "overly pessimistic accounts of fully incommensurable knowledge systems", which is also equally problematic.

Strategies for the Promotion of Intercultural Science Education

Emergence, visibility, and amplification of knowledge and practices of traditional communities are some of the consequences that can be obtained when ISE is proposed (Alvim, 2023). In addition, through contact with this knowledge and practices, a shift in perspective is expected, abandoning the idea of incapacity and inferiority attributed to traditional groups, to understand them as producers of legitimate knowledge (Alvim, 2023). In this context, this review identifies efforts to destabilize the narrative of science as the only valid form of knowledge, as well as possible ways to develop ISE. The following figure shows the main strategies used by some of the studies included in this review (Figure 4).

Figure 4

Strategies used to promote Intercultural Science Education

Strategy	Authorship	Main objectives
Ethnobiology	Amorim & Baptista, 2020; Baptista & Araújo, 2019; Vargas et al., 2014; Silva & Ramos, 2019; Robles-Piñeros et al., 2020.	Investigate traditional knowledge in order to establish a dialogue with scientific knowledge
Contextual Cognition Table (CCT)	Baptista, 2018; Robles-Piñeros et al., 2020; Santos; Baptista & Robles-Piñeros, 2021.	Identify similarities and differences between knowledge systems and negotiate meanings
Production of teaching materials	Bascopé & Velarde, 2016; Castillo, 2021; Monteiro & Zuliani, 2020; Pérgola et al., 2021.	Share with teachers and society possible ways to address themes that stimulate the amplification of traditional knowledge and its approximation with scientific knowledge
Bridges Concepts	Bonan et al., 2020; Chadwik & Bonan, 2018; Gondwe & Longnecker, 2015; Hernández-Barbosa, 2018.	To propose a common theme between traditional and scientific knowledge systems
Communities of Practice (CoP)	El-Hani, 2022; El-Hani & Ludwig, 2024; Ibarra et al., 2022; Orjuela-Osorio, 2023.	Plan intercultural teaching practices with a focus on collaborative efforts and for mutual benefit among researchers, teachers, and communities
Teacher training courses	Baptista, 2015; Martins et al., 2021; Rédua & Kato, 2020; Santos et al., 2021; Sorge et al., 2023.	Stimulate reflections and provide changes in the understanding of the nature of science, applications and implications of science, as well as consideration of cultural diversity

The strategies present in the table above, despite being distinct and having been used in different contexts, complement each other and converge towards a common goal, which is to develop sensitivity to cultural diversity and awaken teaching practices connected to the students' reality. We identified that starting from the investigation of traditional knowledge, through Ethnobiology, it is possible to produce didactic materials. Such experiences demonstrate the possibility of valuing traditional knowledge, while also promoting the learning of scientific knowledge and enhancing the amplification of this knowledge to other environments and cultures (Baptista, 2018; Manetta & Baptista, 2022; Silva & Ramos, 2019).

Another common point presented by the authors is that it is not only about allowing students to perceive the similarities and differences between knowledge systems, but also to recognize how traditional knowledge is used in everyday relationships and results from their practices, and, therefore, should also be considered, negotiating their meanings, and understanding in which contexts traditional and scientific knowledge systems can be used (Santos et al., 2021). In this way, we found that these initiatives can contribute to the formation of students' identity and strengthen their connections, preserving the identity of those who live in these communities (El-Hani & Ludwig, 2024). In addition, they foster care for biodiversity and biocultural memory, forming active agents in their territories (Ibarra et al., 2022).

Although we have found a smaller number intercultural teaching experiences, whether through CoP, which strengthens the relationship between university and basic education teachers from local communities with the aim of planning intercultural teaching practices (El-Hani & Ludwig, 2024), or through listening to the conceptions of teachers and students regarding the definitions of traditional knowledge, science and dialogue between knowledge systems (Orjuela-Osorio, 2023; Peñaloza et al., 2023), and identified only one study focusing on textbook analysis (Flores-Silva et al., 2020), which found that the textbook usually fails to present attempts to dialogue with the students' reality, the results of these experiences seem to converge to alert to the need for truly sensitive teacher training (Uribe-Pérez, 2020) and the production of teaching materials that amplify local diversity (Flores-Silva et al., 2020).

Although there are already initiatives for courses and workshops aimed at this training, sensitive to cultural diversity, the results show that many teachers in training still reproduce an ethnocentric view (Rédua & Kato, 2020). These aspects reveal that the development of a truly intercultural approach is a complex process, which requires time, reflection, and continuous support. For this training to truly bring sensitivity in educators, specific actions of initial or continuing education must be addressed (Martins et al., 2021). However, this does not mean that courses are dispensable. But, when proposing them, it is important to encourage teachers in training to reflect and understand the importance of Intercultural Dialogue in the context of the classroom (Martins et al., 2021). It is important to highlight that it is not only about recognizing diversity, but also considering its particularities and the relationships that can be established between traditional and scientific knowledge systems (Baptista et al., 2023), that is, a form of training that enhances the link between the cultural and environmental context and scientific knowledge (Castillo, 2021).

Challenges and Proposals for Overcoming

Despite the various contributions associated with ISE, the inclusion of different ways of knowing reality, as well as the practices of traditional communities and the development of pedagogical teaching strategies that promote this rapprochement, is still challenging (Valadares & Silveira Júnior, 2020). Both teachers and school managers experience this challenge (Bascopé & Velarde, 2016). Therefore, we have listed significant challenges faced in the development of the ISE, which we have organized into four axes:

i) Structural and institutional barriers (Baptista, 2015; Chadwick & Bonan, 2018; Monteiro & Zuliani, 2020; Robles-Piñeros et al., 2023): rigidity and homogeneity of the school curriculum, limited and often Eurocentric teaching materials, insufficient workload to develop intercultural pedagogical practices, in addition to the lack of autonomy of teachers to adapt content to the cultural context of students. School management and public policies also play a fundamental role, as the absence of clear guidelines makes it difficult to create spaces for dialogue.

ii) Teacher training (Amorim & Baptista, 2020; Bonan et al., 2020; Melo-Brito, 2019; Rédua & Kato, 2020; Rodrigues & Leite, 2020; Rodríguez, 2021): teachers generally do not receive adequate initial or continuing training to recognize the cultural diversity present in the school context, with discussion of the theme being uncommon and the adoption of Eurocentric and transmissive approaches common. Such practices end up having repercussions on the consideration of scientific knowledge as superior, resulting in the non-recognition of various epistemologies. In their study, Baptista et al. (2023) identified that teachers do not seem to master the nature of the science they teach and how to relate it to traditional knowledge, in addition to not feeling safe to act in rural contexts in a dialogical way. This is especially aggravated with teachers who work in culturally diverse classrooms (Chadwick & Bonan, 2018).

iii) Lack of University-School approximation (Baptista, 2015; Baptista & Molina-Andrade, 2021): there is a discontinuity between initial training and school practice that prevents future teachers from being able to bring traditional knowledge and scientific knowledge closer together. As a result, many teachers begin their careers without a clear understanding of how to recognize and value cultural diversity in the classroom.

iv) Difficulties in cultural mediation (Chadwick & Bonan, 2018; Gondwe & Longnecker, 2015; Melo-Brito, 2019; Rodrigues & Leite, 2020): teachers find it difficult to promote intercultural dialogue, often due to a lack of knowledge and the absence of adequate pedagogical strategies. Even when teachers recognize the importance of diversity, they face difficulties in mediation. From this perspective, the lack of experience in the classroom or previous contact with students causes estrangement and, consequently, hinders dialogue (Martins et al., 2021).

In the face of the challenges, the authors suggest convergent proposals for overcoming them aligned with the four utopian theses of interculturalizing and pluralizing science teaching proposed by Riveroll (2021), who proposes the replanning of scientific practice based on the pluralization of the idea of science, scientific knowledge,

curriculum, and didactics. This involves recognizing that science is not unique and that different systems of knowledge can coexist, in order to promote teaching that recognizes invisible groups and their respective knowledge as legitimate forms of knowledge. In addition, it includes developing strategies and teaching materials that value students' cultural knowledge and encourage Intercultural Dialogue (Riveroll, 2021). It is also essential to invest in the initial and continuing education of teachers, ensuring that they are able to critically reflect on the nature of science and develop sensitivity to cultural diversity (Rodríguez, 2021). As an example of strategies to overcome the distance between university and school, Baptista and Molina-Andrade (2021) suggest visits to traditional communities and interviews with their knowledge holders.

Conclusions and Implications

This bibliographic survey plays an important role in presenting and organizing the existing production in its most general tendencies on Intercultural Science Education. In this sense, we present below our considerations based on the analysis of the 50 studies included in this SLR.

As for the definition of ISE, there seems to be a consensus that it is an attitude sensitive to cultural diversity, which recognizes, values, and respects diverse and legitimate ways of producing knowledge beyond the scientific one. It is characterized, therefore, as a space for dialogue between invisible and scientific knowledge. We also found that ISE is based on three aspects: an intercultural attitude with a pragmatist pluralist perspective, which seeks to move away from a posture that relativizes science. In addition, it can be based on the model of partial convergences in three domains (ontological, epistemological, and axiological), which allows considering both similarities and differences between the different knowledge systems, which promotes collaboration, mutual learning, reflections, and ways of learning through intercultural translation, which is its third foundation.

We also noticed that although ISE has been developed with prominence in the Global South, it takes on different perspectives: in countries where the flow of human migration is a reality, ISE aims at the integration of newcomers and assumes a bilingual character. In countries where the diversity of traditional communities is accentuated, ISE emerges as a critique of the consideration of a single legitimate form of knowledge, acting with a bias to develop sensitivity to cultural diversity and value invisible groups and knowledge, as well as indigenous languages. Among the strategies used for the development of ISE, we highlight Ethnobiology articulated with the use of Contextual Cognition Tables (CCT), the creation of didactic materials, Communities of Practice (CoP), and teacher training initiatives.

Regarding the challenges that affect ISE, we identified that structural and institutional barriers, teacher training, lack of University-School approximation, and difficulties in cultural mediation were the main challenges mentioned by the studies. Such challenges lead us to warn that the adoption of the perspective of Interculturality

in the classroom should not be restricted to specific formations, nor should it occur in a superficial, folkloric, or caricatured way, but be critical and committed to diversity. To this end, it is necessary to promote spaces that allow students to develop autonomy and reflection for a critical reading of the local and global reality in which they are immersed, in order to value their origins, as well as the knowledge and practices of the communities to which they belong. It is also important for students to be autonomous in decisions that affect their realities, while preserving identity processes, without losing sight of the objective of understanding scientific ideas.

ISE is an urgent need for the promotion of a diversity-sensitive Science Education that amplifies the voices of invisible groups and knowledge. This requires not only the flexibility of curricula, production of teaching materials, teacher training, approximation between university, school, and communities, and other strategies that recognize and value traditional knowledge, but also public policies that create conditions for Intercultural Science Education to be a possible reality. In view of the above, we hope with this review to contribute so that teachers and researchers can build Intercultural Dialogues in science teaching, in order to allow the approximation of different knowledge systems, considering their similarities, differences, as well as conflicts, negotiations and new meanings that may arise. We believe that these new meanings are the potentially relevant educational horizons for the formation of students, as well as for the recognition of knowledge historically subjugated to scientific knowledge, in its various forms and manifestations.

Authors' Contribution

Conceptualization: Oliveira, M. T. V.; **Data curation:** Oliveira, M. T. V.; **Formal analysis:** Dias, M. A. S.; **Funding acquisition:** author; **Investigation:** Oliveira, M. T. V.; **Methodology:** Oliveira, M. T. V., Dias, M. A. S.; **Project administration:** Oliveira, M. T. V.; **Supervision:** Dias, M. A. S.; **Validation:** Dias, M. A. S.; **Writing – original draft:** Oliveira, M. T. V., Dias, M. A. S.; **Writing – review & editing:** Oliveira, M. T. V., Dias, M. A. S.

Data Availability Statement

The data will be provided upon request.

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