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Review paper

STEM+Intercultural: Integrating STEM Education with Indigenous Ancestral Knowledge, Traditional Knowledge, and Intercultural Contexts. A Systematic Literature Review

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ABSTRACT

STEM education has become an interdisciplinary approach that integrates multiple disciplines to foster students' skills for addressing global and local challenges. It focuses on learning experiences that embrace cultural diversity and promote contextualized learning within educational settings. This review examines the integration of indigenous ancestral knowledge, traditional knowledge, and intercultural contexts within the STEM educational framework. The systematic literature review followed the PRISMA methodology, including searches across four databases Scopus, Web of Science, ScienceDirect, and Taylor & Francis, focusing on studies published between 2020 and 2024 and applying predefined inclusion and exclusion criteria. Sixteen studies were analyzed, employing qualitative, quantitative, and mixed methods approaches across different world regions, with educational experiences situated in rural, indigenous, and intercultural communities at various educational levels. The results reveal a growing trend toward contextualized and integrative STEM teaching that emphasizes the cultural dimensions of indigenous and traditional knowledge. The findings also highlight the challenges and barriers in curriculum integration, persistent epistemic differences, and the role of STEM education as a tool for epistemic justice. In addition, they point to its potential as a foundation for future research on integrating ancestral and traditional knowledge in diverse intercultural contexts.

Keywords: STEM education, ancestral knowledge, indigenous knowledge, traditional knowledge, curriculum, interculturality

STEM education in intercultural environments is a meaningful and inclusive contextualized process that develops students' competencies and life skills in diverse and globalized communities (McLure et al., 2022; Tang et al., 2024). This interdisciplinary approach integrates science, technology, engineering, and mathematics (STEM) with other disciplines, knowledge, and skills to promote relevant competencies that enable students to address global and local challenges in creative and innovative ways (Han et al., 2023). Therefore, to consolidate collaborative networks that address these types of experiences, it is necessary to involve various actors from

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school communities in the development of projects that benefit the territory and connect learning (Birney & McNamara, 2024).

In this regard, over the past few years the implementation of the STEM educational approach has included art, humanities, culture, and diverse contexts, enabling the emergence of the STEM+ approach (Murthi et al., 2024). From this perspective, there is a recognized need to include cultural diversity in the learning and teaching of STEM subjects in educational contexts, considering the presence of indigenous ethnic groups, racial diversity, and minority and excluded communities in different territories (Ferri & White, 2024).

STEM education in intercultural and multicultural contexts can contribute to improved social, cultural, environmental, and political engagement, which has direct implications for students' interest and academic performance. Recent studies show that the quality of teaching in some areas varies significantly between urban and rural environments, highlighting the importance of the educational context in teaching and learning processes, as well as the need for educational policies that are sensitive to territorial differences (Alemany-Arrebola et al., 2025; Gerfanova et al., 2025).

This has led to interest in integrating and complementing ancestral and traditional knowledge with scientific and technological knowledge legitimized in education, thus giving rise to proposals that are contextualized in the territories, inclusive, and socially equitable (Espigares-Gámez et al., 2020). This orientation has enabled research projects to generate meaningful learning by integrating scientific and technological knowledge with the intercultural experiences and realities of school and university students (Starr et al., 2022). These studies demonstrate the potential of STEM education for strengthening scientific learning while incorporating traditional knowledge, cultural narratives, artifacts, and ancestral practices in rural and Indigenous communities (Castagno et al., 2023b).

However, there are still some challenges to consider, such as tensions between integrative and inclusive approaches and decolonial proposals, which create barriers that affect teacher training in interculturality, traditional curriculum, and the limited inclusion of local, traditional, and ancestral knowledge in education systems, as well as low community participation in pedagogical spaces (Seniuk Cicek et al., 2021; Taylor et al., 2023). At the same time, pedagogical proposals are emerging with the presence of students with ethnic or racial diversity and teacher training that includes culture in their pedagogical and curriculum approaches (Añaños & Herreras, 2023).

The theoretical and epistemological orientation of this review is grounded in well-established traditions in intercultural, equity-oriented, and decolonial education. Frameworks such as culturally relevant pedagogy and funds of knowledge have long emphasized the legitimacy of learners' cultural repertoires and community-based knowledge as foundational resources for science and STEM education (Ladson-Billings, 1995; Moll et al., 1992). Likewise, scholarship on Indigenous science and cross-cultural science education has highlighted epistemic plurality and dialogue between Indigenous knowledge systems and Western scientific traditions (Aikenhead, 1996; Cajete, 2000).

From a Latin American perspective, critical interculturality and decolonial pedagogy further frame education as an ethical–political project oriented toward epistemic justice and the recognition of historically marginalized knowledges (Dietz, 2017; Walsh, 2009). These connections clarify the theoretical grounding of the emerging STEM+intercultural perspective within a broader scholarly tradition in STEM education (Suarta et al., 2022).

Several approaches to STEM education have focused on the integration and complementarity of ancestral and traditional knowledge with scientific knowledge (López-Quiñones et al., 2023), to identify their potential so that innovative pedagogical and curriculum proposals can be designed based on these approaches. Therefore, this review maps and systematizes experiences and research that demonstrate significant progress and contribute to the consolidation of a possible STEM approach that integrates aspects related to interculturality, opening the discussion on the consolidation of new educational approaches focused on the development of scientific skills that recognize local, traditional, and ancestral knowledge.

In accordance with the above, this review aims to understand the characteristics, challenges, trends, and opportunities of integrating the STEM+ approach in intercultural contexts, highlighting relevant theoretical aspects that can guide future research in STEM education and seek to consider ancestral and traditional knowledge in intercultural contexts. Therefore, this systematic review is guided by three research questions:

- RQ1: What are the characteristics of studies conducted on the integration of STEM with indigenous ancestral knowledge, traditional knowledge, and intercultural contexts?
- RQ2: How are indigenous, local, and ancestral knowledge integrated with scientific knowledge in studies on intercultural STEM education?
- RQ3: What are the challenges, tensions, and opportunities associated with designing and implementing STEM+ integration programs with ancestral and traditional knowledge?

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These research questions will provide clues that will enable us to characterize studies on the subject described above in terms of their characteristics, issues, trends, lines of research, impact factor of the scientific journals where the articles have been published, among other aspects that will help to elucidate the theoretical and epistemological corpus that emerges when ancestral and traditional knowledge is included in STEM education..

METHODS

A systematic review of the literature was conducted on STEM educational experiences in intercultural contexts that highlight ancestral and traditional knowledge, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009; Petro-Petro et al., 2024) and established criteria of quality, transparency, and rigor (García-Parra & Pérez Sepulcre, 2021). This approach ensured methodological transparency, replicability, and consistency throughout the review process.

The aim of this review was to identify trends, challenges, and opportunities for future research in STEM education in intercultural environments. The study included the Scopus, Web of Science (WoS), Taylor & Francis (T&F), and ScienceDirect databases, as they bring together publications of high scientific impact and relevance (López-Belmonte et al., 2023). The following sections describe the search strategy, inclusion and exclusion criteria, study selection, and data analysis process.

Search strategy and eligibility criteria

The search strategy was conducted using four indexed databases—Scopus, Web of Science (WoS), Taylor & Francis (T&F), and ScienceDirect—selected for their impact and relevance within the scientific community. Keywords combined with Boolean operators were used in all databases according to the following search equation: (STEM OR STEAM OR STEM+) AND (intercultural OR interculturality) AND ("ancestral knowledge" OR "traditional knowledge") AND education. In addition, inclusion and exclusion criteria were defined to ensure the relevance of the studies selected for this systematic review, as detailed in **Table 1**.

Table 1

Inclusion and exclusion criteria

Inclusion Criterion	Exclusion Criterion
IC1: research articles only	EC1: studies published as essays, conference proceedings, review articles, reports, and preprints
IC2: articles published between 2020-2024	EC2: articles published before 2020 or in 2025
IC3: open access articles	EC3: articles not available for full-text download
IC4: English and Spanish	EC4: studies in languages other than English and Spanish, such as French, German, among others
IC5: subject areas: Social Sciences, Arts and Humanities, Education, Education-Teaching, and Educational Sciences	EC5: studies conducted that did not have an educational purpose
IC6: related to STEM education in the context of intercultural issues, ancestral knowledge, and traditional knowledge	EC6: subject areas such as Engineering, Computer Science, and Medicine, which include the acronym STEM in their publications

Data identification and screening

In conducting the full search, filters were applied in line with the established inclusion and exclusion criteria. The search for information was conducted in May 2025 and yielded 483 articles, of which 228 came from WoS, 13 from Scopus, 57 from T&F, and 185 from ScienceDirect. All were extracted and imported in RIS format into the Rayyan systematic review reference manager (Ouzzani et al., 2016), in which the bibliography was organized, duplicate references were removed, the screening process was carried out, and the full text of the selected studies was subsequently reviewed.

In the first review phase, 18 duplicate records were identified; however, after verification, only 9 duplicates were removed. A total of 436 documents were excluded based on title, abstract, and keywords. In this process, the articles were classified as included or excluded according to the previously established eligibility criteria, leaving 38 articles for full-text review. The selected studies were downloaded and imported into Rayyan (Ouzzani et al., 2016). Finally, after reaching a consensus and considering the inclusion criteria, 16 articles were selected for detailed analysis in the review, see **Figure 1.**

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Figure 1

Process of identifying and selecting studies based on PRISMA

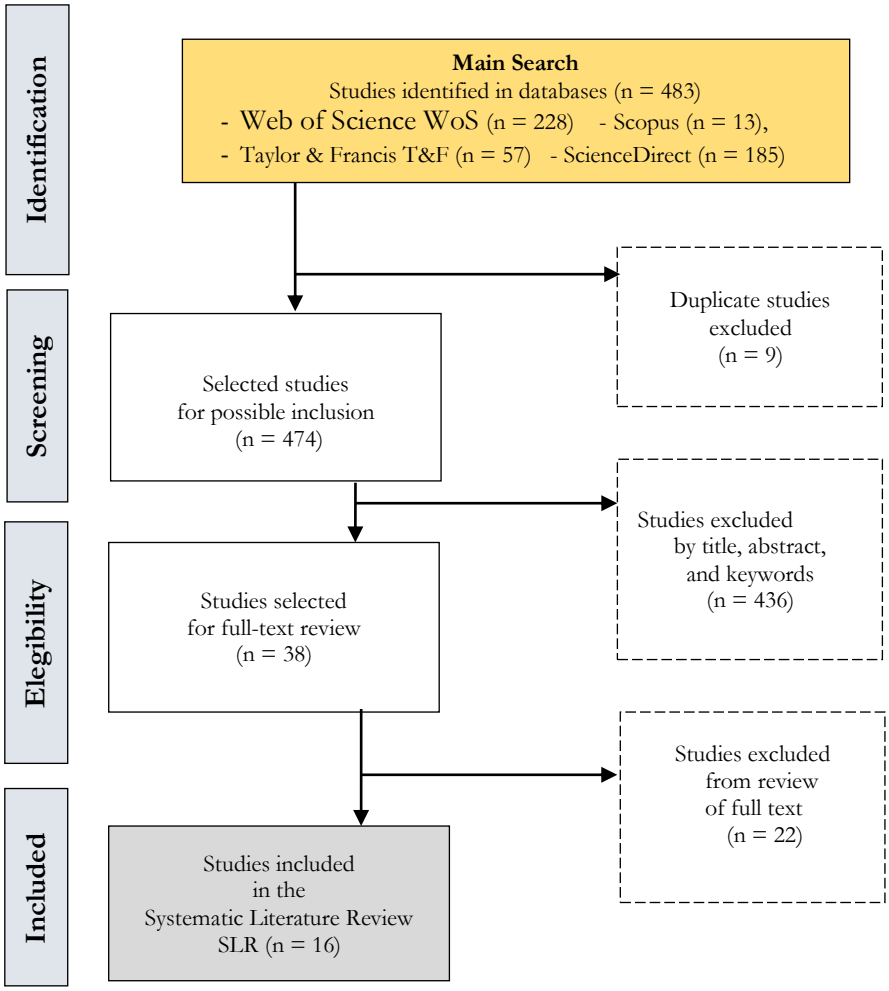

Figure 1 provides a visual summary of the identification, screening, eligibility, and inclusion process applied in this systematic review, following PRISMA guidelines.

Data monitoring

The data monitoring process for the documents selected for full text was carried out using the Rayyan program (Ouzzani et al., 2016), from which 16 articles were selected for inclusion in the systematic review. During this stage, the authors reviewed relevant aspects of the publications, such as the type of article, authors, article title, date of publication, context, methodology, educational level, theoretical approach, findings, challenges, and recommendations. The review protocol was repeated and adjusted until consensus was reached among the authors to ensure rigor in the review.

Data analysis and presentation

Sixteen research articles were analyzed in depth and organized into three categories related to the three research questions posed in the review (RQ1, RQ2, RQ3). To this end, the authors used content analysis and categories, followed by the development of theoretical frameworks based on the selected research. Finally, the analytical process enabled the identification and synthesis of key patterns, challenges, and implications for STEM education integrating ancestral and traditional knowledge, based on the ancestral and traditional knowledge of the 16 studies selected for the systematic literature review.

To conduct the qualitative synthesis, the full texts of the selected studies were systematically examined and organized according to the three research questions (RQ1–RQ3). Relevant information was extracted through a structured charting process that included study characteristics, educational context, methodological approach, theoretical orientation, and reported findings. These data were compared across studies through an iterative reading process to identify recurring themes, patterns, and conceptual convergences. Based on this comparative

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analysis, emerging categories were progressively refined through discussion and consensus among the authors, ensuring analytical rigor, transparency, and coherence in the interpretation of qualitative insights.

The results presented in the following section derive directly from this qualitative synthesis and are organized according to the three research questions guiding the review.

RESULTS

This section presents the main findings of the systematic review, organized according to the research questions and focused on publication trends, geographical distribution, methodological approaches, and emerging categories related to STEM+ education in intercultural contexts. The results were addressed based on the research questions proposed as the object of study, characterizing the studies, possible research trends, geographical distribution, methodologies, and levels of training in which they were developed.

Likewise, the integration of the STEM+ educational approach into intercultural educational processes that incorporate traditional, ancestral, and cultural knowledge was explored. This allowed the discovery of predominant patterns and possible gaps in knowledge in this field of research for future relevant lines of investigation. Below are the aspects that could offer a global vision of STEM integration in intercultural contexts.

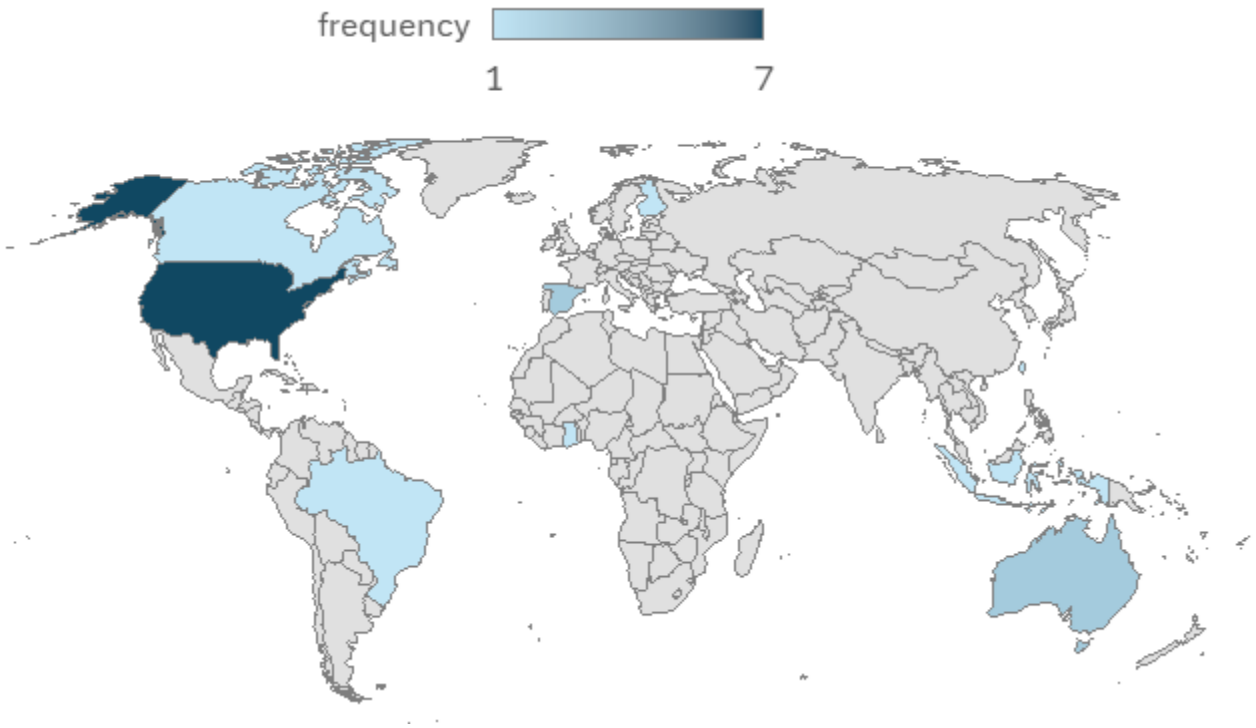
Studies on the integration of STEM with indigenous ancestral knowledge, traditional knowledge, and intercultural contexts (RQ1)

The 16 studies analyzed between May and June 2025 were published between 2020 and 2024 in high-impact journals. For 2020 (the year of the COVID-19 pandemic), one publication was found, but for the years 2021, 2022, and 2023, four, five, and four publications were found, respectively. This shows a slight increase in interest in this line of research. However, in 2024, two publications were found, slightly decreasing the volume of publications. These results suggest that intercultural dimensions remain underrepresented in STEM+ research, which could indicate that it is a line of work that has been little addressed in the field of educational research. Therefore, it would be necessary to develop educational proposals and publications that achieve an increase in their dissemination in the coming years.

The geographical distribution of the studies reviewed spans North, Central, and South America, Europe, Asia, Africa, and Oceania, including collaborative research across countries. Six studies were conducted in the United States (n = 6), while one study each was identified in Canada, Brazil, Spain, Finland, Taiwan, Indonesia, and Australia (n = 1 per country). In addition, three studies involved international collaborations (n = 3), including Korea–Australia, USA–Ghana, and Jamaica–Spain (Figure 2).

Figure 2

Frequency of publications by countries



Scientific output in the databases over the last five years was also compared for the selected publications. WoS had the highest number of articles, with seven distributed as follows: 1 in 2020, 3 in 2022 (the peak), 2 in 2023, and 1 in 2024, thus confirming scientific publication over time. Similarly, in Scopus, publications per year totaled 5 articles distributed between the years 2020, 2021, 2022, and 2024, showing a similar pattern to that found in WoS. The other two databases show fewer publications, with ScienceDirect having 2 articles in 2023 and T&F having 2 articles in 2021 (**Table 2**). This shows that the volume of publications in this line of research is still in its infancy and has a lot of potential to be explored.

Table 2

Geographical distribution of publications

Country	Study
USA	(Herrera et al., 2022)
USA	(Estrada et al., 2022)
USA	(Starr et al., 2022)
USA	(Castagno et al., 2023)
USA	(Bueno et al., 2022)
USA	(King et al., 2023)
USA / Ghana	(Kim et al., 2024)
Canada	(Seniuk Cicek et al., 2021)
Brazil	(Cunha de Araújo & Fernandes da Silva, 2021)
Spain	(Fernández-Oliveras et al., 2021)
Jamaica/Spain	(Espigares-Gámez et al., 2020)
Finland	(Taylor et al., 2023)
Australia	(Jamie, 2021)
Korea/Australia	(Ei Seul et al., 2023)
Indonesia	(Zidny & Eilks, 2022)
Taiwan	(Chen & Wu, 2024)

Regarding the visibility of publications and the impact factor of journals, the SCImago Journal & Country Rank (SJR) platform and Web of Science Platform Clarivate were consulted. Among the aspects investigated were the Q quartile where the journal is located, the name of the journal, the SJR 2024 value, and the title of the article for the 16 selected research papers. It should be noted that of the 16 publications, 11 are in 9 Q1 quartile journals with SJR values between 2.606 and 0.238, three of them in three Q2 quartile journals with SJR values between 0.650 and 0.688, and two of them in two Q3 quartile journals with SJR values between 0.381 and 0.279. In other words, 69% of publications are in Q1 journals, 19% in Q2, and 12% in Q3. Looking at these metrics, it can be inferred that the line of research is of interest to high-impact journals that are relevant to the scientific community, paving the way for greater visibility of STEM+ research in intercultural contexts and under the influence of traditional, cultural, and ancestral knowledge.

Likewise, in May 2025, the citations received from the 16 articles published in the 14 journals in the databases were reviewed, and the two databases with the highest number of citations were selected, the information for which is presented in (**Table 3**). According to the information found, the five journals with the highest number of citations were classified: first in the ranking is Education Sciences with 53 citations in three articles, noting that one of the three has 32 citations; second is BioScience with 28 citations in one article; third is International Journal of STEM Education with 25 citations in one article, fourth is Teaching in Higher Education with 22 citations in one article, and fifth is Australian Journal of Chemistry with 12 citations in one article. Regarding citations, in May 2025, the 16 articles had a total of 179 citations in publications indexed in the databases reviewed.

It is noteworthy that the Q1 Education Sciences journal ranks first with 25.7% of citations in its three articles, followed by research such as that of Zidny and Eilks (2022) with 32 cites (17.9%), Fernández-Oliveras et al. (2021) with 14 cites (7.8%) and King et al. (2023) with 7 cites received (3.9%) show the highest number of citations. These results could indicate a growing interest in the development of STEM+ studies in intercultural contexts and open the door to research in a field that is still unexplored but scientifically relevant in high-impact journals, contributing to the appropriation and social transfer of scientific knowledge.

On the other hand, regarding the methodological approach of the studies, it was found that 56.3% of the articles present qualitative designs, 31.2% mixed designs, and 12.5% quantitative designs. This reflects the predominance of qualitative studies in this field of study over quantitative ones, while mixed studies show relevance with a second part of the methods used. Also, the educational levels in the methodological designs observed in Table 4 were established, showing that only 6.3% are in preschool education, which is a low percentage and deserves research interest, as does 18.8% in basic education, but with 31.3% in secondary education, which is the main focus of action, but then decreases to 18.8% in middle school and, most importantly, 43.8% in higher education, as it allows the scientific community to identify lines of action (**Table 4**).

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Table 3

SJR ranking of journals and articles included in the study

Q	Journal	C SJR	Article	Cites
Q1	International Journal of STEM Education	2.606	Intercultural competence outcomes of a STEM living–learning community	16 Scopus
	BioScience	2.365	Culture and Quality Matter in Building Effective Mentorship Relationships with Native STEM Scholars	16 Scopus
	Teaching and Teacher Education	1.700	Educators' perspectives related to preparatory education and integration training for immigrants in Finland	2 Scopus
	AERA Open	1.659	"It Was Hard, and It Still Is...": Women of Color Navigating HSI STEM Transfer Pathways	2 Scopus 7 WoS
	Science Education	1.367	"It hurts to do work like that": Nature and frequency of culturally based ethical barriers for Indigenous people in STEMM	0 Scopus 1 WoS
	Teaching in Higher Education	1.327	Indigenizing Engineering education in Canada: critically considered	11 WoS 11 T&F
	PLoS ONE	0.803	The World Smarts STEM Challenge: A promising approach to fostering STEM and global competence skills for adolescents in the US and Ghana	0 Scopus
	Education Sciences	0.730	1. Implementation of a Playful Microproject Based on Traditional Games for Working on Mathematical and Scientific Content	6 Scopus
			2. Learning about Pesticide Use Adapted from Ethnoscience as a contribution to Green and Sustainable Chemistry Education	21 Scopus 11 WoS
			3. "The Work I Do Matters": Cultivating a STEM Counterspace for Black Girls through Social-Emotional Development and Culturally Sustaining Pedagogies	4 Scopus 3 WoS
	Sustainability	0.688	Integrating Science, Technology, Engineering, and Mathematics (STEM) into Indigenous Education for Sustainability: The Development and Implementation of a Curriculum Based on Disaster Prevention for Young Children	0 WoS
Q2	Frontiers in Education	0.650	"That Was the Biggest Help": The Importance of Familial Support for Science, Technology, Engineering, and Math Community College Students	6 Scopus 4 WoS
	Cogent Education	0.602	Apinayé art: a case study in a Brazilian indigenous school	1 Scopus 1 T&F
	Acta Scientiae	0.238	Games as STEAM learning enhancers. Application of traditional Jamaican games in Early Childhood and Primary Intercultural Education	9 Scopus
Q3	Asia-Pacific Science Education	0.381	Development and Impact of an Intercultural STEAM Program on Science Classroom Creativity	2 Scopus 2 WoS
	Australian Journal of Chemistry	0.279	Macquarie–Yaegl Partnership: Community Capability Strengthening Through Western and Indigenous Science	7 Scopus 5 WoS

Table 4

SJR ranking of journals and articles included in the study

Study	Design	Level	Main topics
(Herrera et al., 2022)	Qualitative	Higher	Afro-American women and STEM education
(Cunha de Araújo & Fernandes da Silva, 2021)	Qualitative	Basic	Indigenous knowledge and education
(King et al., 2023)	Qualitative	Higher	STEM, Black girls, and social-emotional learning
(Bueno et al., 2022)	Qualitative	Higher	STEM, interculturality, and family
(Taylor et al., 2023)	Qualitative	Secondary and middle	Intercultural and teacher formation
(Espigares-Gámez et al., 2020)	Qualitative	Basic	Intercultural, STEM and traditional knowledge
(Fernández-Oliveras et al., 2021)	Qualitative	Basic	STEAM, games, and traditional knowledge
(Seniuk Cicek et al., 2021)	Qualitative	Higher	Indigenous knowledge, engineering, and STEM
(Chen & Wu, 2024)	Qualitative	Preschool	STEM, curriculum, and indigenous knowledge
(Starr et al., 2022)	Mixed	Higher	STEM and interculturality
(Castagno et al., 2023a)	Mixed	Higher	Ethical and culturally based barriers for Indigenous participation in STEM
(Zidny & Eilks, 2022)	Mixed	Secondary	Green chemistry and indigenous knowledge
(Jamie, 2021)	Mixed	Secondary and Higher	STEM, science, and indigenous knowledge
(Kim et al., 2024)	Mixed	Secondary and middle	STEM and interculturality
(Ei Seul Kim et al., 2023)	Quantitative	Secondary and middle	STEAM, interculturality, and creativity
(Estrada et al., 2022)	Quantitative	Higher	Native people and STEM education

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Knowledge regarding STEM+ education in intercultural contexts (RQ2)

In relation to the second research question (RQ2), the studies reviewed show a connection between traditional and ancestral knowledge and scientific epistemologies in STEM+ education. The studies highlight diverse, contextualized pedagogical and curriculum experiences developed at different educational levels, ranging from early childhood education to higher education.

It is evident that this ancestral and traditional knowledge is not limited to anecdotal records but is recognized as local epistemologies capable of strengthening the teaching of science, mathematics, technology, and other areas in the territory, taking a critical stance toward traditional approaches to science and technology.

A first key finding indicates the recognition of indigenous knowledge as a legitimate and epistemic local source for the scientific and technological teaching and learning process. Ancestral and traditional science is highlighted to enrich students' critical thinking and sustainability in the teaching of a natural science such as chemistry (Zidny & Eilks, 2022), or proposals for territorial cultural solutions based on Rukai indigenous knowledge in Taiwan as a pedagogical strategy for preventing natural disasters (Chen & Wu, 2024). Both cases can be considered not only as curriculum adaptations but also as school innovation using traditional and ancestral science.

A second recurring pattern reveals cultural and pedagogical recovery based on traditional, narrative, and intercultural artistic examples. In this case, traditional Caribbean games mediated by Project-Based Learning can develop scientific and mathematical skills from a STEAM and ethnomathematics approach (Espigares-Gámez et al., 2020), in the same way, art and play can preserve and transmit scientific knowledge and wisdom through interculturality (Cunha de Araújo & Fernandes da Silva, 2021; Fernández-Oliveras et al., 2021). These studies reveal that the STEM+ educational approach can be used and applied in processes of cultural identity, cultural memory, and knowledge transmission in students from historically excluded contexts.

An additional relevant aspect concerns the connection between ancestral and traditional knowledge and the communities in these territories. Research shows how indigenous peoples include spiritual, agricultural, and natural practices in their curriculum based on an everyday, contextualized, and territorial science (Estrada et al., 2022). Furthermore, indigenous contributions to engineering in STEM fields offer critical solutions to dominant technology and environmental sustainability (Seniuk Cicek et al., 2021).

However, the integration of this knowledge and expertise is not without controversy and tension. It is also evident that the lack of teacher training in interculturality has led to the design of curriculum that are not very inclusive, thus reducing the integration of knowledge, cultural diversity, and racial diversity, which has a minimal impact on educational equity and STEM curriculum guidelines (Herrera et al., 2022; Taylor et al., 2023).

From a critical epistemological posture, the tensions between indigenous communities and their ancestral, traditional, local knowledge under ancestral cosmogony and traditions, and Western scientific communities with methodical protocols are analyzed, thus leading to dilemmas of validation and legitimization of knowledge (Herrera et al., 2022; Jamie, 2021).

Finally, ancestral and traditional knowledge is conceived as pertinent processes of co-construction of knowledge, based on ethnic diversity and interculturality (Kim et al., 2024; King et al., 2023; Starr et al., 2022). Similarly, families have an important cultural role in STEM educational trajectories. They should not be separated from the community; open and thoughtful dialogues should be built together (Bueno et al., 2022). Moreover, cultural mentoring promotes the integration and retention of indigenous students in STEM programs (Estrada et al., 2022).

The studies reviewed show that integrating traditional and ancestral knowledge with STEM+ scientific knowledge can lead to an emerging category that has been termed STEM+ intercultural education. Here, local epistemologies, cultural preservation, curriculum contextualization, and community co-construction of knowledge could be addressed. Such integration of knowledge under a STEM+intercultural approach could be seen not only as a static process, but also as a line of innovation and resistance to dominant educational norms, as evidenced by the integration that may arise from the findings derived from the review.

Thus, the emerging category of STEM+intercultural education is not limited to the curriculum itself, but also highlights epistemic, pedagogical, and sociocultural processes. For this reason, five emerging categories are revealed from this central category, which are articulated and substantiated by the research analyzed in this review.

The emerging categories revealed are: 1) recognition of indigenous knowledge as a legitimate and local epistemic source for the scientific and technological teaching and learning process, 2) cultural and pedagogical recovery based on traditional, narrative, and intercultural artistic examples, 3) linking ancestral and traditional knowledge with communities from the territories, 4) teacher training in interculturality, and 5) ancestral and traditional knowledge as relevant processes of co-construction of knowledge, based on ethnic diversity and interculturality, as detailed in (**Figure 3**).

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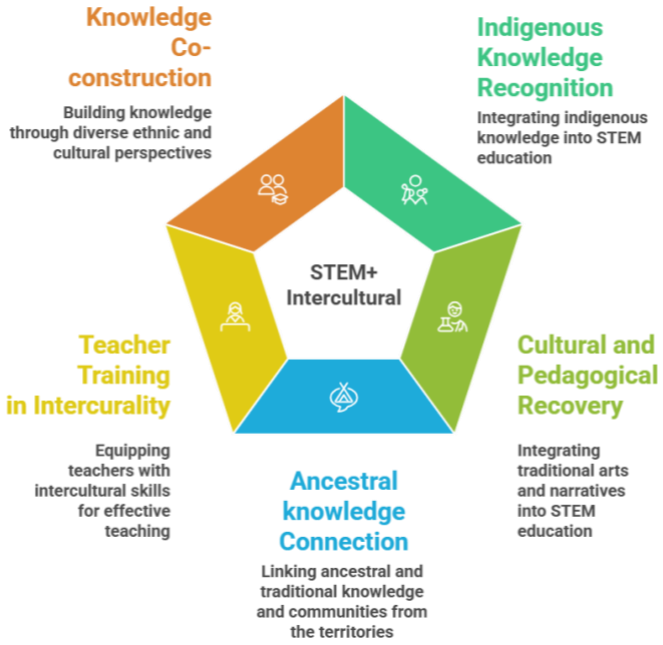
Figure 3
Emerging categorical foundations of STEM+intercultural



These categories converge to challenge traditional educational models and propose a situated, pluralistic, and cultural STEM+ education. This STEM+intercultural approach can enable a space for educational innovation, epistemic resistance, and social transformation, where science and technology engage in horizontal dialogue with ancestral, traditional, and local knowledge.

Challenges, opportunities, and tensions associated with STEM+ education in intercultural contexts (RQ3)

The research reviewed shows that the development of STEM+ integration projects based on dialogue between ancestral, local, and traditional knowledge faces challenges, tensions, and opportunities. One of the difficulties encountered focuses on the lack of flexibility in the curriculum under educational guidelines and standards, with priority given to the homogenization of knowledge. Teachers still show weaknesses in integrating legitimized indigenous knowledge into science and technology teaching under educational curriculum guidelines (Taylor et al., 2023). Similarly, it is evident that students of Afro-descendant and indigenous origin tend to experience barriers in accessing and remaining in STEM projects, courses, and degree programs, generally caused by differences in gender, ethnicity, culture, or country of origin (Estrada et al., 2022; Herrera et al., 2022). This highlights the need to achieve greater sustainability for this type of project and program focused on interculturalism, creativity, and pedagogy, which can form the basis for the transformation of public education policies.

A further aspect worth highlighting is the tensions in epistemological differences that arise when integrating indigenous knowledge with methodical scientific knowledge. However, authors such as Zidny & Eilks (2022) in their research, they propose that ethnoscience based on green chemistry develops critical thinking. Fernández-Oliveras et al. (2021) and Espigares-Gámez et al. (2020), sustain that ancestral and traditional knowledge should not be developed as examples or anecdotes, but should be incorporated into the curriculum as pedagogical tools that can legitimize knowledge in STEM areas.

Despite these barriers, the review shows opportunities for educational innovation and epistemological justice. Kim et al. (2023) show that creativity, cultural identity, and emotions are strengthened through intercultural STEAM+ programs and the integration of scientific and artistic knowledge and expertise. Jamie (2021) highlights the integration between indigenous and Western teachers in a teaching model that legitimizes epistemological coexistence and the local community curriculum. This is complemented by the work of Seniuk Cicek et al. (2021), where it is argued that indigenous contributions to engineering processes provide sustainable, cultural, and relevant solutions.

A group of additional research reviewed evidence of other challenges and opportunities in intercultural STEM+ integration with local, traditional, and ancestral knowledge. These studies contribute to the importance of sensitizing teachers to local epistemologies in curriculum practices. (Starr et al., 2022). Afro-pedagogies are

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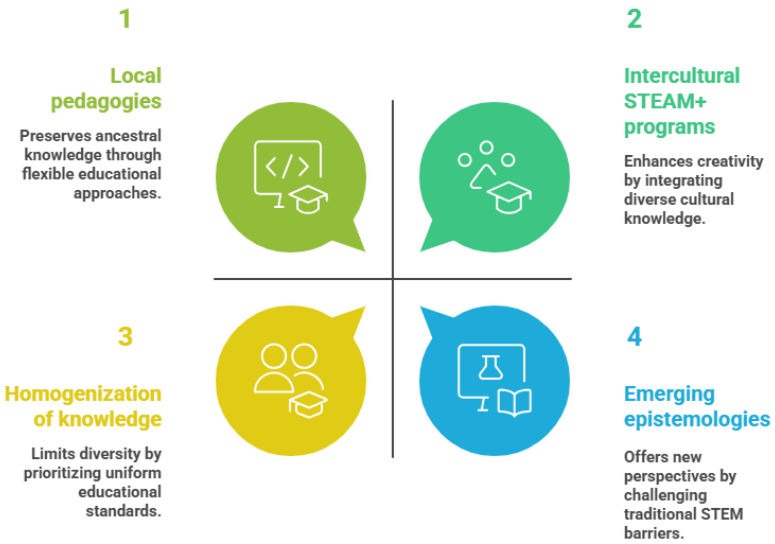
also presented as cultural resistance and preservation among girls and women in STEM sciences (King et al., 2023). Now, from a community perspective, family support has become a decisive factor in combating incomplete educational trajectories based on interculturality (Bueno et al., 2022).

Finally, Cunha de Araújo & Fernandes da Silva (2021) and Jamie (2021) show that, although there are successful cases of integration, these tend to be local and are not aligned with institutional education policies, which highlights the need to strengthen networks and support structures for public education policies.

The review reveals significant tensions in the implementation of STEM+intercultural education, specifically in the rigidity of standardized curriculum guidelines, which prioritize the homogenization of knowledge and do little to incorporate local and ancestral epistemologies. This, added to the barriers faced by students due to gender, ethnicity, culture, or country of origin, limits access to and retention in STEM programs and perpetuates dynamics of exclusion. However, the findings show that local and intercultural pedagogies are emerging which, by integrating scientific knowledge with ancestral artistic knowledge, strengthen creativity, cultural identity, and emotions, and challenge dominant educational frameworks. Thus, local, traditional, and ancestral knowledge emerge as epistemologies for epistemological justice, cultural recovery, and the social appropriation of knowledge (Figure 4).

Figure 4

Emerging categorical challenges, opportunities, and tensions STEM+intercultural



Overall, the findings reveal persistent tensions between standardized curricular frameworks that prioritize the homogenization of knowledge and the emergence of localized, intercultural pedagogies grounded in ancestral and traditional epistemologies. While these tensions continue to limit access, participation, and retention in STEM programs for historically marginalized groups, the reviewed studies also demonstrate that culturally situated STEM+ approaches offer meaningful opportunities for epistemic justice, cultural recovery, and the social appropriation of scientific knowledge.

DISCUSSION

The findings of this systematic literature review show a growing trend toward integrating the STEM educational approach into contexts rich in cultural diversity among countries or minority groups, with ancestral knowledge from indigenous ethnic groups and traditional and local knowledge from communities. These studies are not isolated efforts; they highlight the need to rethink epistemological dominance in science and technology education in STEM areas. For this reason, the pedagogical, scientific, cultural, and environmental value of indigenous, traditional, and ancestral knowledge is recognized. Moreover, these efforts are not limited to complying with educational inclusion regulations but are also integrated into educational curriculum with emerging integrative approaches based on interdisciplinarity and transdisciplinarity, which supports the need for an approach STEM+ intercultural (Thibaut et al., 2018).

From a broader theoretical perspective, these findings resonate with well-established frameworks such as Funds of Knowledge and culturally relevant pedagogy, which emphasize the educational value of community-based knowledge, cultural practices, and everyday experiences as legitimate resources for learning (Moll et al., 1992; Ladson-Billings, 1995). In this sense, the STEM+intercultural practices identified in this review extend these perspectives into the field of STEM education by demonstrating how indigenous, traditional, and local

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epistemologies can be meaningfully integrated into science and technology curricula, not as supplementary content, but as foundational elements for teaching, learning, and knowledge construction.

However, the integration of traditional and ancestral indigenous knowledge into STEM curricula to achieve change through critical interculturality and epistemic diversity should not be carried out in a general or superficial manner. Studies show that the epistemological and methodological path advances from the decoloniality of knowledge, preserving the culture and cosmovision of indigenous peoples, as well as seeking transformations of realities in educational models with epistemic and cultural diversity (Herrera et al., 2022; Starr et al., 2022). It is therefore evident that STEM+ programs that integrate traditional games, ancestral artifacts, indigenous technology and science, and ancestral narratives can enhance creativity, contextualized learning, interdisciplinary and transdisciplinary thinking, and cultural preservation. This opens possibilities for meaningfully involving minority communities that have historically been excluded from the educational process in innovative and localized learning spaces (Ei Seul et al., 2023; Espigares-Gámez et al., 2020; Fernández-Oliveras et al., 2021; Jamie, 2021).

An additional aspect identified in the review relates to the design of curriculum capable of recognizing and legitimizing local, traditional, and ancestral knowledge as valid epistemes in the educational community, beyond only experiential examples. In this regard, thinking about curriculum design centered on a STEM+intercultural approach should draw on ethnoscience and traditional intercultural games to enhance the teaching of science, mathematics, and technology through critical thinking, cultural identity, and context. In this way, it will be possible to promote spaces for questioning Western scientific hegemony in education and seek the collective construction of diverse and emerging epistemologies (Espigares-Gámez et al., 2020; Fernández-Oliveras et al., 2021; Zidny & Eilks, 2022).

Furthermore, the integration of what has been termed STEM+intercultural in the context of this review is an approach that has been gaining ground over the last five years, although the volume of publications remains limited. However, it is an emerging line of research that is worth exploring, to continue increasing the scientific community's interest in addressing local epistemologies in education, through curriculum that meaningfully integrates pedagogical practices based on interculturality with scientific expertise. This curricular orientation aligns with longstanding calls in multicultural and Indigenous science education to promote epistemic plurality and sustained dialogue between Western scientific traditions and diverse knowledge systems.

In this regard, the challenges and needs for training programs that take a STEM+intercultural approach are largely marked by the tensions that arise when attempting to adopt local pedagogies within educational institutions, due to limitations associated with non-contextualized and inflexible curriculum, lack of teacher training in intercultural approaches, and in other cases, the scarcity of educational resources for communities (Taylor et al., 2023). However, implementing this type of approach is a commitment that could help overcome learning barriers and close some educational gaps by empowering the community and implementing more contextualized curriculum (Castagno et al., 2023a; Seniuk Cicek et al., 2021; Zidny & Eilks, 2022).

Yet, the review shows that there are epistemic barriers and tensions due to the lack of teacher training in intercultural education, which has an impact on the implementation of curriculum that excludes local, traditional, and ancestral knowledge (Herrera et al., 2022; Taylor et al., 2023). These findings allow us to document theoretical differences between protocols based on Eurocentric scientific methods and indigenous cosmogonies in areas such as the natural sciences, where validity and legitimacy present contextual differences. It is therefore necessary to move toward deeper dialogues aimed at developing public education policies for curriculum integration (Castagno et al., 2023a; Jamie, 2021).

Nevertheless, some of the findings suggest the possibility of a STEM+intercultural approach as a valuable element in educational innovation. In this regard, research such as that by Kim et al (2023) highlight creativity and global citizenship in intercultural programs, while Seniuk et al. (2021) showcases indigenous engineering contributions to STEM education from a critical and sustainable perspective. Along the same lines, Ei Seul et al. (2023) and Bueno et al. (2022), highlight the importance of contextualized cultural mentoring with family support to ensure educational trajectories in STEM programs. This points to significant advances in the implementation of innovative strategies that bring science teaching into dialogue with the knowledge of communities, giving it legitimacy and greater possibilities for achieving a relevant and contextualized education.

Considering the above, the contributions of this review focus on proposing that education from a STEM+intercultural approach should not only be perceived as anecdotal, but as an epistemological contribution to the curriculum from a local and ancestral perspective. It is therefore emphasized that local, traditional, indigenous, and Afro-descendant knowledge can constitute elements for scientific and pedagogical innovation, rather than being considered solely as pedagogical resources resulting from isolated experiences and initiatives.

Similarly, it is proposed that teacher training guided by an intercultural approach and the development of inclusive public education policies are necessary for the integration of knowledge and the generation of contextualized and sustainable knowledge over time, since the community and the territory are vital for the

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teaching of science, based on everyday dialogue and cultural practices (Chen & Wu, 2024; Cunha de Araújo & Fernandes da Silva, 2021; Estrada et al., 2022; Starr et al., 2022).

Finally, it is suggested that future studies should be conducted to explore how education programs with a STEM+intercultural approach can be consolidated as a commitment that leads to the formulation of educational policies considering the context and territory. In this way, communities will not only be beneficiaries but also true participants in the construction of more relevant and contextualized curricula in response to the demands and challenges posed by 21st-century education.

LIMITATIONS AND FUTURE DIRECTIONS

In conducting this review, research published in high-impact journals was considered under previously defined inclusion and exclusion criteria, resulting in the final selection of 16 articles. However, despite a rigorous search of four of the world's leading scientific databases, it is possible that publications indexed in other databases or repositories with less circulation, which could further enrich this emerging field of research, were not included.

Another limitation is that only publications in Spanish and English were considered, which could exclude research conducted in other languages and developed from South American, African, and Oceanic epistemologies. Future reviews could broaden this scope by incorporating studies published in additional languages and regional journals, particularly from the Global South, to further enrich comparative and intercultural perspectives in STEM education research.

In future research, it is recommended to develop quantitative studies that address the integration of the STEM+Intercultural approach in different contexts and levels of education, thereby enabling us to measure the impact on learning, the transformation and adoption of curriculum, and the social and cultural appropriation of STEM education. Similarly, it is interesting to address proposals on teacher training in intercultural contexts, specifically in the design of contextualized curriculum and participatory community methodologies with indigenous communities, Afro-descendants, and minority groups, so that a sufficient body of knowledge can be developed to contribute to the design of public policies that promote STEM+intercultural education as a field of contextualized pedagogical curriculum integration, cultural preservation, and local epistemologies, thus achieving Education for All in the 21st century.

These directions align with the mission of the European Journal of STEM Education to advance culturally responsive and inclusive STEM pedagogies that promote equity and global citizenship. Building on these perspectives, it is recommended to design and evaluate intercultural STEM teacher training programs that integrate ancestral and local knowledge into pedagogical practice. Such initiatives could promote culturally responsive teaching models, foster equity in science education, and strengthen the connection between community knowledge and formal education systems.

CONCLUSION

This systematic literature review sought to understand the characteristics, challenges, trends, and opportunities of integrating the STEM+ approach in intercultural contexts. Accordingly, the analysis of the 16 selected articles revealed that the integration of an educational approach called STEM+intercultural that considers indigenous ancestral knowledge, traditional knowledge, and the characteristics of local contexts, constitutes an emerging field of research that is growing and has rich potential for the educational sphere.

The results demonstrate that local knowledge must be recognized as legitimate epistemes and not merely anecdotal proposals, as they offer opportunities for curricular integration, cultural preservation, and consolidation of ancestral epistemologies as an essential part of education. From this perspective, the findings of this review situate STEM+intercultural education within a broader continuum of research on culturally responsive, intercultural, and decolonial pedagogies. By evidencing how ancestral and traditional knowledge function as epistemic resources in STEM teaching, the review extends concepts such as Funds of Knowledge and Indigenous science education into contemporary STEM curricular debates, offering a contextualized and theoretically grounded contribution to the field.

In this sense, a key and fundamental aspect is that the incorporation of ancestral knowledge into scientific expertise not only broadens the teaching and learning process in STEM areas, but also challenges the hegemony of traditional scientific approaches, offering sustainable, critical, and contextualized pedagogical alternatives. This is based on the fact that experiences reviewed in different regions of the world highlight territories, community practices, and cultural languages as fundamental elements that must be considered in the articulation and design of STEM+ curriculum, which contribute to the development of meaningful learning, a sense of belonging, and the cultural identity of students.

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However, studies also reveal recurring challenges and barriers such as rigid curricula, limited teacher training in intercultural issues, epistemic tensions between indigenous ancestral knowledge and Western scientific expertise, and limitations in access to and retention in STEM pathways for indigenous students, students of African descent, ethnic communities, and minority groups. These aspects evidence the need for inclusive educational policies that recognize cultural diversity as a fundamental component of the educational system.

Complementarily, there is a horizon of opportunities for creativity, local community resilience, and contextualized critical pedagogy. Possibilities are opened for initiatives that integrate art, play, mentoring, and family support to consolidate intercultural educational spaces that transmit knowledge and strengthen community participation and cultural preservation. In this sense, education from a STEM+Intercultural perspective is projected as a strategy for the co-construction of knowledge and for the exercise of cultural autonomy by indigenous peoples. Overall, the findings position STEM+intercultural education as a meaningful contribution to contemporary debates in STEM and multicultural education, highlighting its potential to advance epistemic justice, curricular relevance, and socially responsive educational practices grounded in local and ancestral knowledge.

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Ethical statement

This study is a systematic literature review and did not involve human participants or animals. Therefore, ethical approval and informed consent were not required.

Competing interests

The authors declare no competing interests.

Author contributions

The authors contributed equally to this work in terms of conceptualization, methodology, formal analysis, data curation, and visualization. All authors contributed to the writing of the original draft and participated in the review and editing of the manuscript. All authors have read and approved the final version of the manuscript.

Data availability

The data supporting the findings of this systematic literature review were obtained from publicly available databases, including Scopus, Web of Science (WoS), Taylor & Francis, and ScienceDirect. The search strategy, including search strings and eligibility criteria, is described in the methodology section to ensure transparency and reproducibility. All relevant data are included within the article and its references.

AI disclosure

The authors used artificial intelligence (AI) tools to support language editing and text refinement. All content was critically reviewed, validated, and approved by the authors, who take full responsibility for the final version of the manuscript.

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