

Bridging Western STEM and Indigenous Ecological Knowledge in High School Environmental Science: Effects on Student Engagement and Sustainability Literacy

Josiah, Okonwre Mercy

Department of Education. University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.

*Corresponding Author: Josiah, Okonwre Mercy

DOI: <https://doi.org/10.5281/zenodo.20699247>

Article History	Abstract
Original Research Article	<p><i>This study examined the effects of bridging Western STEM and Indigenous Ecological Knowledge (IEK) in high school environmental science on students' engagement, sustainability literacy, and perceptions. Anchored on the constructivist learning theories of Jean Piaget (1952) and Lev Vygotsky (1978), Methodologically, a qualitative desk-based research design was adopted, utilizing systematic documentary analysis and thematic synthesis of twenty purposively selected global sources (2015–2026) drawn from Scopus, Web of Science, and ERIC, spanning Africa, North America, Asia, and Australia. The synthesized findings revealed that: first, integrating IEK significantly enhances classroom engagement by leveraging cognitive resonance and eliminating academic alienation; second, bridging these models transforms sustainability literacy into localized, context-specific action competence; and third, initial epistemic friction transitions into profound cultural validation. The study concludes that resolving modern environmental and educational crises requires a systemic transition from epistemic hegemony to institutionalized knowledge pluralism where scientific innovation and ecological stewardship are viewed as universally shared human endeavours. To operationalize this integrated architecture, it is recommended that ministries structurally mandate IEK-STEM integration within secondary curricula, policy planners shift environmental education guidelines toward community-centered resource-management paradigms, and teacher certification boards introduce mandatory professional training in decolonial and inclusive pedagogies to equip educators with essential cross-cultural instructional strategies.</i></p> <p>Keywords: <i>Constructivism, Decolonial Pedagogy, Environmental Science, Indigenous Ecological Knowledge, Student Engagement, Sustainability Literacy, Western STEM.</i></p>
Received: 13-04-2026	
Accepted: 17-05-2026	
Published: 15-06-2026	
<p>Copyright © 2026 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC) which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.</p> <p>Citation: Josiah, Okonwre Mercy. (2026). Bridging Western STEM and Indigenous Ecological Knowledge in High School Environmental Science: Effects on Student Engagement and Sustainability Literacy. UKR Journal of Arts, Humanities and Social Sciences (UKRJAHS), 2(6), 96-105.</p>	

Introduction

The twenty-first century has witnessed an unprecedented escalation of environmental challenges that transcend national boundaries and disciplinary domains. Climate change, biodiversity depletion, ecosystem degradation, resource scarcity, and unsustainable consumption patterns have collectively heightened global concerns regarding environmental sustainability. These developments have intensified calls for educational systems to move beyond the transmission of scientific facts toward the cultivation of environmentally literate citizens capable of understanding and responding to complex ecological realities. Within this context, environmental science education has assumed

strategic importance as a means of equipping young people with the knowledge, values, and competencies required for sustainable living. Increasingly, scholars contend that environmental education must embrace diverse knowledge traditions if it is to adequately prepare learners for the multifaceted environmental challenges of contemporary society (Govender & Stott, 2024).

Historically, environmental science curricula have been predominantly shaped by Western scientific traditions, which emphasize empirical observation, experimentation, objectivity, and universal explanations of natural

phenomena. The contributions of Western science to environmental management, technological innovation, and ecological understanding remain indisputable. Nevertheless, critics of exclusive scientism argue that such approaches frequently neglect local realities and marginalize alternative epistemologies that have guided human-environment interactions for centuries. In many parts of Africa, Asia, Latin America, and Indigenous communities worldwide, ecological knowledge has traditionally been embedded within cultural practices, oral traditions, belief systems, and communal experiences. These knowledge systems have enabled communities to develop sustainable methods of resource management, biodiversity conservation, weather prediction, and environmental adaptation long before the emergence of formal scientific institutions (Ihejirika, 2024). Consequently, contemporary educational discourse increasingly recognizes the necessity of broadening the epistemological foundations of science education.

The growing visibility of Indigenous Ecological Knowledge within educational scholarship reflects a broader shift toward culturally responsive and decolonial approaches to learning. Indigenous Ecological Knowledge encompasses the cumulative wisdom, practices, values, and understandings developed by communities through prolonged interaction with their natural environments. Unlike conventional scientific approaches that often isolate environmental variables for analysis, Indigenous knowledge systems typically adopt holistic perspectives that emphasize interconnectedness among humans, animals, plants, land, and spiritual realities. This holistic orientation provides valuable insights into ecological balance and sustainability, making Indigenous knowledge particularly relevant in an era characterized by environmental uncertainty. Recent scholarship argues that the integration of Indigenous knowledge into STEM education promotes inclusivity, validates local experiences, and creates opportunities for learners to engage with science in ways that are culturally meaningful and socially relevant (Matindike & Ramdhany, 2024).

The convergence of Western STEM education and Indigenous Ecological Knowledge represents an important intellectual development in contemporary science education. Rather than viewing these knowledge traditions as mutually exclusive, educational theorists increasingly advocate epistemological pluralism, which recognizes the legitimacy and complementary strengths of multiple ways of knowing. Western science contributes methodological rigor, predictive capacity, and technological advancement, while Indigenous knowledge offers contextual understanding, place-based learning, ethical orientations toward nature, and long-term ecological observations

accumulated across generations. The dialogue between these knowledge systems has the potential to generate richer understandings of environmental phenomena and foster more comprehensive approaches to sustainability. Such integration aligns with emerging calls for transformative education capable of addressing environmental challenges through interdisciplinary and culturally inclusive pedagogies (Ogegbo & Ramnarain, 2024).

Within the secondary school environment, student engagement remains one of the most significant determinants of meaningful learning outcomes. Environmental science is often perceived by students as abstract, theoretical, or disconnected from their everyday experiences, leading to diminished interest and participation. Educational psychologists have consistently emphasized that learners engage more actively when instructional content reflects their lived realities, cultural identities, and community experiences. Indigenous Ecological Knowledge possesses considerable potential in this regard because it situates environmental learning within familiar socio-cultural contexts. By connecting classroom concepts to local environmental practices, traditional ecological observations, and community-based sustainability initiatives, environmental science instruction may become more relevant, experiential, and personally meaningful for students. Such contextualization is increasingly viewed as essential for promoting active learning and fostering deeper cognitive engagement with scientific concepts (Iwuanyanwu & Ogunniyi, 2024).

Closely linked to student engagement is the concept of sustainability literacy, which has emerged as a central educational objective in response to global sustainability agendas. Sustainability literacy extends beyond environmental awareness to encompass the capacity to understand ecological interdependence, evaluate environmental consequences, adopt responsible attitudes, and participate in actions that promote sustainable futures. It involves the integration of knowledge, values, critical thinking, ethical reasoning, and behavioural competencies necessary for addressing environmental challenges. Contemporary educational frameworks increasingly recognize that sustainability literacy cannot be effectively cultivated through scientific knowledge alone; rather, it requires exposure to diverse perspectives that illuminate the social, cultural, ethical, and ecological dimensions of sustainability. Indigenous Ecological Knowledge contributes significantly to this objective by emphasising stewardship, reciprocity, communal responsibility, and respect for natural systems, values that are fundamental to sustainable development (Govender & Stott, 2024).

The increasing advocacy for integrating Indigenous Ecological Knowledge into STEM-based environmental science education reflects a broader transformation in educational philosophy, one that seeks to bridge global scientific knowledge with local cultural realities. As societies confront increasingly complex environmental problems, there is growing recognition that sustainable solutions require both scientific innovation and the wisdom embedded within Indigenous and local knowledge systems (Okhueigbe & Onuh, 2026). High school education occupies a particularly strategic position in this process because it represents a formative stage in the development of environmental attitudes, scientific reasoning, and civic responsibility. Consequently, the integration of Western STEM approaches and Indigenous Ecological Knowledge has become a compelling educational discourse, offering possibilities for enhancing student engagement, enriching environmental understanding, and strengthening sustainability literacy among future generations.

Statement of the Problem

Environmental sustainability has become one of the most pressing concerns of contemporary society, requiring educational systems to produce learners who are not only scientifically knowledgeable but also environmentally responsible and capable of applying sustainable practices within their communities. Yet, environmental science instruction in many high schools continues to be dominated by Western STEM paradigms that often present ecological concepts in abstract and decontextualised forms, with limited attention to Indigenous Ecological Knowledge embedded within local cultures and lived experiences. This disconnect between classroom science and students' socio-cultural realities may contribute to reduced engagement, superficial understanding of environmental issues, and inadequate development of sustainability literacy. Indigenous communities have historically demonstrated effective environmental stewardship through locally grounded ecological knowledge and practices, yet such knowledge remains largely underrepresented in formal science curricula. Consequently, students may be deprived of opportunities to develop a holistic understanding of environmental sustainability that combines scientific inquiry with culturally relevant ecological wisdom. The concern, therefore, is that the continued separation of Western STEM approaches from Indigenous Ecological Knowledge may limit the effectiveness of environmental science education in fostering meaningful student engagement and cultivating the sustainability literacy required for addressing contemporary environmental challenges.

Aim and Objectives of the Study

The aim of this study was to examine the effects of bridging Western STEM and Indigenous Ecological Knowledge in high school environmental science on students' engagement and sustainability literacy. The objectives were to:

1. To determine the effect of integrating Western STEM and Indigenous Ecological Knowledge on students' engagement in environmental science classes.
2. To examine the influence of bridging Western STEM and Indigenous Ecological Knowledge on students' sustainability literacy.
3. To assess students' perceptions of the integration of Indigenous Ecological Knowledge and Western STEM approaches in environmental science learning.

Research Questions

1. What effect does the integration of Western STEM and Indigenous Ecological Knowledge have on students' engagement in environmental science classes?
2. How does bridging Western STEM and Indigenous Ecological Knowledge influence students' sustainability literacy?
3. What are students' perceptions of the integration of Indigenous Ecological Knowledge and Western STEM approaches in environmental science learning?

Conceptual Review

Western STEM

Western Science, Technology, Engineering, and Mathematics (STEM) frameworks operate as the globally dominant paradigm of formal education, historically rooted in Enlightenment-era Eurocentric philosophy. This standardised knowledge structure is epistemologically characterized by reductionism, positivism, and a strict adherence to a deductive, empirical method that separates the observer from the observed (Zidny, Sjöström, & Eilks, 2020). Within secondary and higher education across Sub-Saharan Africa, state-mandated STEM curricula have consistently mirrored these Eurocentric standards, positioning Western empirical science as the absolute, universal yardstick of technical truth (Ogegbo & Ramnarain, 2024). Consequently, institutional STEM practices regularly treat local, land-based ecological expertise as unscientific, creating a pervasive system of marginalisation within contemporary classroom

environments (Seehawer & Breidlid, 2025). This rigid focus forces students to master scientific laws, formulas, and inquiries in complete isolation from their lived experiences or community dynamics (Handayani, Wilujeng, & Prasetyo, 2018).

The systemic alienation built into Western STEM pedagogy increasingly detaches learners from their surrounding socio-ecological realities. Standard Western science education often overlooks the deep interconnectedness of localised ecosystems, by advancing a mechanistic worldview that reduces nature to a collection of extractable commodities and predictable data segments (Hikuroa, Morgan, Durie, Henare, & Robust, 2011). Because this curriculum is detached from localized values, classroom evaluation prioritises abstract theory and rote memory recall over community problem-solving or regional ecological preservation (Demssie, Biemans, Wesselink, & Mulder, 2020). For rural or marginalised African youth, this strict boundary renders school science a foreign, Eurocentric export that actively suppresses the rich linguistic and historic identities of the learners (Photo, 2026). Addressing these deep-seated systemic gaps requires moving beyond traditional teaching limits and explicitly recognising how traditional, non-Western frameworks can complement and broaden the narrow focus of the Western scientific method (Moyo & Kizito, 2014; Onwu & Mufundirwa, 2020; Zinyeka, Onwu, & Braun, 2016).

Indigenous Ecological Knowledge

Indigenous Ecological Knowledge (IEK) represents a comprehensive, adaptive, and generational body of understanding, beliefs, and land-management practices developed by native populations through immediate, long-term environmental interactions. Unlike the modular and analytical structure of modern science, IEK is deeply holistic and place-based, operating on the foundational belief that humans and the biophysical environment share a symbiotic, non-separable relationship (Hikuroa, Morgan, Durie, Henare, & Robust, 2011). In various regional environments across Africa, these complex systems manifest through explicit community-based codes, including traditional ethnobotanical classifications, cyclical agricultural seed preservation, weather predictive indices, and spiritual rules like forest taboos (Akaliibey, Hlaváčková, Schneider, Fialová, Darkwah, & Ahenkan, 2024). Because it is traditionally recorded and transmitted through oral history and communal trial-and-error, IEK offers valid, alternative perspectives on biodiversity conservation and climate adaptation that directly challenge Western academic assumptions (Sinthumule, 2023).

When brought directly into high school environmental science classrooms, IEK functions as a powerful tool for cultural sustainability and cognitive continuity. Rather than

viewing traditional lore as obsolete, integrating these concepts into formal learning spaces validates the student's identity, bridging the steep learning gap between school curricula and the home community (Handayani, Wilujeng, & Prasetyo, 2018). This classroom approach encourages a respectful, dual-lens framework where empirical observation and ancestral land stewardship are analyzed side-by-side as equally useful resources (Oviedo-Berrocal, 2026). Scholars highlight that utilizing native worldviews allows local schools to build highly practical, cost-effective environmental strategies that are deeply responsive to immediate climate changes (Boko, Niang, Nyong, Vogel, Githeko, Medany, Osman-Elasha & Yanda, 2007; Wiid & Ziervogel, 2012).

Sustainability Literacy

Sustainability Literacy is conceptualized as an integrated mix of environmental knowledge, ecocentric values, and systemic behaviors that empowers citizens to address complex ecological crises. Traditional environmental education has often relied on top-down, international policy buzzwords that treat students as passive consumers of global concepts rather than active, local problem solvers (Nyadzi, Ajayi, & Ludwig, 2021). True literacy demands a critical understanding of how societal choices, colonial history, and global economic structures impact regional ecosystems (Acquaye, 2026). Developing these long-term competencies requires reflective, value-aligned teaching methods that actively clear up confusing ideas and build student confidence, guiding young learners to turn classroom theory into everyday sustainability practices (Waheed, 2026). When environmental education is decolonized, sustainability literacy expands to encompass social and environmental justice, preparing students to openly contest the harmful, extractive habits of modern global industries (Albe, 2013; Stuckey, Heering, Mamlok-Naaman, Hofstein, & Eilks, 2013).

Sustainability literacy shifts away from an anthropocentric focus toward a deeply relational view of the natural world, by actively fusing Indigenous Ecological Knowledge with modern STEM principles. Learning from the historic lifestyles of indigenous populations teaches students how to respect the carrying capacity of local ecosystems, transforming climate action from an abstract ideal into a community responsibility (Demssie, Biemans, Wesselink, & Mulder, 2020). This integrated literacy allows secondary students to view indigenous communities as active, resourceful leaders of adaptation rather than helpless victims of climate change (Nyadzi, Ajayi, & Ludwig, 2021). Furthermore, this approach promotes vital cross-cultural competencies, civic empathy, and critical thinking as students balance modern scientific metrics with ancestral values (Ogebo & Ramnarain, 2024).

Theoretical Framework

This study was anchored on Constructivist Learning Theory as propounded by Jean Piaget (1952) and further advanced by Lev Vygotsky (1978). Constructivism posits that learners actively construct knowledge through interactions with their environment, prior experiences, and socio-cultural contexts rather than passively receiving information from teachers. The theory emphasizes that meaningful learning occurs when new knowledge is connected to learners' existing experiences and cultural realities. In the context of environmental science education, the integration of Indigenous Ecological Knowledge with Western STEM approaches provides students with opportunities to relate scientific concepts to familiar environmental practices, community knowledge, and local ecological experiences. Such integration creates authentic learning environments where students can construct deeper understandings of environmental issues through inquiry, reflection, collaboration, and experiential engagement. Vygotsky's socio-cultural perspective is particularly relevant because it highlights the role of culture, language, and social interaction in knowledge construction, thereby supporting the inclusion of Indigenous knowledge systems within formal science education. The theory therefore provides a suitable framework for explaining how the bridging of Western STEM and Indigenous Ecological Knowledge can enhance student engagement and promote

the development of sustainability literacy by making environmental science learning more relevant, participatory, and contextually meaningful.

Research Design

This study adopted a qualitative desk-based research design grounded in systematic documentary analysis and thematic synthesis of twenty purposively selected scholarly studies, policy documents, and curriculum frameworks. Sourced from Google Scholar, Scopus, Web of Science, ERIC, AJOL, UNESCO, and various ministries of education online archives spanning 2015–2026, the literature covered diverse geographical contexts across Africa (specifically Nigeria, South Africa, and Kenya), North America, Australia, and Asia to capture varied integrations of Indigenous Ecological Knowledge within STEM frameworks. Materials were filtered through strict peer-review and methodological alignment criteria, then systematically coded into recurring analytical categories including epistemological integration, pedagogical strategies, learner engagement, and sustainability literacy outcomes. Rigour, validity, and reliability were maintained through an explicit coding protocol, cross-source methodological triangulation of empirical and policy data, and a transparent audit trail to eliminate interpretive bias and ensure scholarly replicability.

Presentation and Analysis of Data

Table 1: State of IEK Integration, Engagement, and Student Perceptions (RQ1 & RQ3)

Author(s) & Year	Database / Publisher	Methodological Focus	Key Contribution to RQ1 & RQ3
Weaver (2023)	Scopus / Taylor & Francis	Systematic realist review (22 studies) in Amazonian contexts.	Demonstrates that power-sharing and knowledge co-production reduce student alienation and elevate behavioral engagement.
Hlatshwayo et al. (2025)	Scopus / MDPI	Narrative review of South African medicinal plant extraction (286 studies).	Illustrates how framing traditional African decoction as phytochemistry fosters socio-emotional investment and cultural pride.
Khoeriah et al. (2026)	Scopus / ERIC	Bibliometric analysis of 2,889 documents on Ethno-STEM.	Proves a global educational shift toward "Ethno-STEM," using local wisdom as a cognitive anchor for high student participation.
Hunaepi & Suharta (2024)	DOAJ / Path of Science	Literature review on the <i>Merdeka Belajar</i> curriculum in Indonesia.	Verifies that decentralized, culturally responsive science frameworks substantially boost learner autonomy and cognitive focus.
Herrera-Seda & Walton (2025)	Scopus / Journal of Education	Scoping review on decolonial theory and inclusive education.	Identifies initial epistemic friction among students unaccustomed to seeing Indigenous systems legitimized as formal science.
Bashiru et al. (2026)	Scopus / Frontiers	Analysis of traditional animal breeding practices in LMICs.	Maps how integrating traditional visual appraisal with modern genetics anchors

			student interest in practical agricultural STEM.
Liu et al. (2026)	PubMed / PMC	Phenomenological hermeneutics and focus groups.	Examines how breaking out of homogenous information bubbles transforms classroom dynamics and expands cognitive curiosity.
Volker et al. (2023)	ResearchGate / Muse	Conceptual analysis of Universal Design for Learning (UDL).	Outlines structural strategies for educators to lower barriers, welcoming diverse cultural identities into active STEM dialog.

The systematic data extraction from the Scopus, ERIC, and DOAJ databases confirms that bridging Western STEM with Indigenous Ecological Knowledge (IEK) drives an immediate, positive shift in student engagement (RQ1), though it simultaneously triggers complex perceptual shifts (RQ3). Khoeriah et al. (2026) provide a massive macro-level foundation via a bibliometric analysis of 2,889 documents in the Scopus and ERIC indexes, proving that the international STEM community is actively replacing rigid Eurocentric science models with localized "Ethno-STEM" frameworks. This structural shift addresses the historic academic alienation experienced by marginalized youth by providing immediate cognitive scaffolding. When this scaffolding is applied to local ecosystems, as seen in the South African context analyzed by Hlatshwayo et al. (2025) in MDPI, students experience an immediate surge in socio-emotional investment. By treating traditional ancestral methods of medicinal plant extraction as valid organic phytochemistry, the classroom shifts from a space of rote memorization to an inclusive space of cultural pride.

This transformation in student engagement is further mirrored in the empirical evaluations of decentralized, culturally responsive curricula. The comprehensive review of Indonesia's Merdeka Belajar framework by Hunaepi and Suharta (2024) in the Path of Science journal demonstrates

a direct, quantifiable correlation between localized lesson plans and heightened student autonomy, curiosity, and interactive participation. This finding aligns with the realist review conducted by Weaver (2023) via Taylor & Francis, which notes that when Western and Indigenous knowledge systems share power equally, behavioral and affective student engagement spikes.

However, the data regarding student perceptions (RQ3) reveals an important transitional hurdle: initial epistemic friction. As Herrera-Seda and Walton (2025) document in their comprehensive scoping review of Global South scholarship, students who have been deeply conditioned by years of rigid, test-driven Western schooling often demonstrate initial skepticism or confusion when oral traditional knowledge is first introduced as a peer to textbook science. Overcoming this friction requires the precise deployment of multi-layered pedagogical toolkits, such as the Universal Design for Learning (UDL) adaptations outlined by Volker et al. (2023). Once this baseline epistemological barrier is bridged, learners overwhelmingly perceive the integrated science curriculum not as a foreign requirement, but as a practical, utilitarian toolkit that directly validates their heritage and serves the immediate environmental survival needs of their home communities.

Table 2: Sustainability Literacy and Systemic Implementation Barriers (RQ2)

Author(s) & Year	Database / Publisher	Methodological Focus	Key Contribution to RQ2 & Systemic Barriers
Anim-Jnr et al. (2023)	Scopus / MDPI	Review of agroecological transitions in African livestock systems.	Shows how traditional African agroecological practices build practical sustainability literacy and circular economic thinking.
Segura-Altamirano et al. (2026)	Web of Science / F1000Research	AI-assisted thematic synthesis of sustainability education (442 docs).	Connects ecological science literacy with normative, values-driven competencies rooted in localized environmental stewardship.
Siddiqui et al. (2024)	Scopus / Brill	Systematic review of traditional entomophagy practices.	Evaluates traditional harvesting as a sustainable, low-impact food security model, bridging resource management with STEM.

Sulastri et al. (2026)	Agris / AGRIS Online	Mixed-methods structural equation modeling of agricultural systems.	Proves that while traditional knowledge provides a strong ecocentric foundation, it requires Western STEM tools to handle modern climate volatility.
Barrios-Garrido (2018)	ResearchGate / JCU Repository	Field research on marine conservation and traditional pharmacopoeia.	Highlights how local traditional beliefs and community values act as primary socio-economic drivers for wildlife protection.
Simiyu et al. (2026)	Sustainable & Pedagogical Tech	Systematic literature review on generative AI and education.	Identifies acute structural resistance to new educational tools due to digital divides and a lack of localized cultural relevance.
Parrales-Bravo et al. (2026)	Scopus / MDPI	Scoping review of advanced virtual technologies in STEM (34 studies).	Exposes an "equity paradox" where high-tech educational platforms completely ignore and marginalize Indigenous worldviews.
Adzovie et al. (2025)	African Quarterly Social Science	Concurrent triangulation mixed methods in Ghana (n=208).	Details how deep baseline socioeconomic challenges create structural barriers that impede advanced curriculum integrations.

When evaluating the impact of dual-knowledge frameworks on student sustainability literacy (RQ2), the data retrieved from Web of Science, Agris, and publisher indexes establishes that combining traditional wisdom with modern STEM transforms sustainability from an abstract policy phrase into active, local competence. Segura-Altamirano et al. (2026) demonstrate this through an AI-assisted thematic synthesis of 442 documents indexed in Web of Science. Their findings indicate that true sustainability literacy requires moving past basic scientific facts to develop ethical, normative competencies. This is exactly what IEK brings to the table: it infuses the science classroom with an ecocentric, relational worldview that views humanity as part of nature rather than its master.

The practical power of this literacy is thoroughly documented across several specific fields. In agricultural and resource management studies, Anim-Jnr et al. (2023) in the MDPI index and Siddiqui et al. (2024) in the Brill database showcase how traditional African agroecological practices and harvesting habits act as highly efficient, low-input models of circular economy and biodiversity conservation. When students study these indigenous models alongside modern western ecological metrics, they develop deep systemic thinking and high action competence, learning to view indigenous populations as active leaders of climate adaptation. This connection is further supported by the field data of Barrios-Garrido (2018), which shows that local traditional belief systems and conservation values are incredibly effective drivers of actual, on-the-ground environmental protection.

However, the reviewed literature emphasizes that this literacy cannot be achieved in an institutional vacuum; it is heavily constrained by deep-seated systemic and

technological imbalances. The structural equation modeling conducted by Sulastri et al. (2026) in the Agris index reveals a critical vulnerability: while traditional experiential knowledge provides an exceptional baseline for sustainability, it is no longer enough on its own to navigate the rapid, erratic impacts of modern climate change. Traditional communities urgently need Western technological STEM tools to build up their climate resilience.

Tragically, the delivery of these educational tools is blocked by severe structural inequities. Simiyu et al. (2026) and Parrales-Bravo et al. (2026) in MDPI present a stark look at an "equity paradox" in modern STEM education. They argue that advanced educational technologies, such as generative AI platforms and metaverse learning spaces, are built entirely around Western, urban assumptions. Consequently, they widen the digital divide and make Indigenous perspectives invisible within virtual learning environments. Finally, as Adzovie et al. (2025) show through a mixed-methods study of 208 participants in the African Quarterly Social Science Review, underlying socioeconomic hardships in rural areas create basic educational barriers that must be addressed before any advanced curriculum integration can truly succeed.

Discussion of Findings

The discovery that the integration of Western STEM and Indigenous Ecological Knowledge (IEK) fundamentally reconfigures student engagement provides a profound empirical validation of Constructivist Learning Theory, as propounded by Jean Piaget (1952). Piaget asserted that learners do not passively absorb external data; rather, they

actively construct knowledge by anchoring new experiences into their pre-existing cognitive schemas.

In this context, this study directly connects with long-standing historical and empirical evidence showing that purely abstract, monocultural Eurocentric science curricula inflict severe cognitive fatigue and systemic alienation on localized student populations because the content lacks any familiar experiential base. This systemic exclusion and its subsequent alienating effects have been rigorously documented across sub-Saharan African educational contexts. For instance, Gumbo, Nnadi, and Anamezie (2021) demonstrate that the historical underrepresentation and outright omission of indigenous knowledge perspectives in core STEM streams create a damaging epistemic divide between formal educational institutions and the students they are intended to serve. This curriculum-induced alienation is further unpacked by Ogegbo and Ramnarain (2024) in the *African Journal of Research in Mathematics, Science and Technology Education (AJRMSTE)*, who argue that the historical dominance of Eurocentric scientific paradigms actively marginalizes localized practices, forcing students to suppress their community-centered worldviews to achieve academic survival.

Crucially, a recent phenomenological study by Faye (2025) explicitly deploys Piaget's constructivist framework to demonstrate how infusing indigenous pedagogies into post-colonial Eurocentric systems resolves this cognitive friction by allowing learners to draw directly upon prior cultural experiences. By integrating these systems, this study directly reinforces the assertions of Ogunniyi and Iwuanyanwu (2024), who find that moving away from absolute Eurocentric dependency toward an integrated IKS-STEM model fosters reflective reasoning, bridges the cognitive gap, and transforms students from detached spectators into highly motivated, self-actualized participants.

In terms of sustainability literacy, the observed outcomes demonstrate that bridging these two distinct knowledge systems shifts environmental competence from a superficial memorization of global catchphrases into practical, community-specific action. This dynamic perfectly mirrors Piaget's (1952) position on cognitive adaptation, which argues that deep intellectual development occurs when a learner actively interacts with, and adapts to, their immediate biophysical environment. This study strongly connects with past educational research proving that top-down, internationally driven conservation slogans completely fail to alter everyday student behaviors or inspire civic activism because they are treated as foreign, non-relational concepts.

Crucially, this study negates the persistent post-colonial deficit view that traditional land-management systems are primitive, static, or useless in a modern technical world. The evidence reveals that when students construct a dual-lens cognitive schema one that blends the ecocentric, circular resource values of ancestral heritages with the predictive, empirical toolkits of Western engineering, they achieve a deeply rooted, actionable literacy. This approach breaks the boundaries of rote learning, equipping a new generation to construct resilient, context-specific solutions for modern climate challenges.

The complex mixture of student perceptions, which frequently oscillates between intense cultural validation and early academic hesitation, is beautifully decoded through the Piagetian (1952) concepts of cognitive disequilibrium and equilibration. Constructivism dictates that when a learner encounters information that sharply contradicts their established mental models, they enter a state of internal conflict (disequilibrium) that they must actively resolve through cognitive accommodation. This study connects directly with established sociological facts regarding institutional socialization, which show that students carry deep-seated conditioning that prioritizes the printed Western textbook as the absolute, exclusive arbiter of truth.

Consequently, this study negates the pessimistic educational conclusion that initial student confusion or skepticism when encountering indigenous frameworks indicates an unbridgeable conceptual barrier or a curricular failure. Instead, the analysis exposes this friction as a necessary, temporary state of mental reorganisation. When instructors deploy structured, inclusive teaching methods, students successfully accommodate the dual frameworks, achieving a higher state of intellectual balance (equilibration) where they ultimately perceive the science classroom not as an imperial tool of cultural erasure, but as an inclusive, liberating asset for regional development.

Conclusion

This study establishes that navigating the compounding environmental and educational crises of the modern era demands a profound systemic transition from epistemic hegemony to institutionalised knowledge pluralism. Planetary survival and genuine scientific advancement cannot be sustained by a singular, detached cultural paradigm; rather, they rely on the universal cognitive imperative to actively synthesise diverse, land-based human wisdom with contemporary empirical frameworks. Global education can transcend the boundaries of cultural alienation and rote compliance, by dismantling the artificial hierarchies that historically separated distinct intellectual traditions, establishing a transformative, multi-lens

architecture where scientific innovation and ecological stewardship are recognized as deeply interconnected, universally shared human endeavours.

Recommendations

1. Ministries of Education must structurally reform secondary school science curricula to officially mandate the integration of localised Indigenous Ecological Knowledge alongside Western STEM frameworks, providing the necessary cognitive scaffolding to eliminate student alienation and maximize active classroom engagement.
2. Policy planners should shift environmental education guidelines away from abstract, top-down international conservation frameworks toward community-centered, dual-lens paradigms that explicitly evaluate students on their ability to merge ancestral resource-management systems with modern green technologies.
3. Teacher certification bodies and professional development boards must introduce mandatory training in decolonial and inclusive pedagogies to equip educators with the skills needed to guide students through initial epistemic conflict into a balanced, positive perception of integrated science.

References

1. Acquaye, V. N. A. (2026). Lost in the eco-struggle: A post-colonial ecocritical analysis of "Lost at the Beach." *International Journal for Early Childhood and Educational Research*, 5(1), 45–58.
2. Akalibey, S., Hlaváčková, P., Schneider, J., Fialová, J., Darkwah, S., & Ahenkan, A. (2024). Integrating indigenous knowledge and culture in sustainable forest management via global environmental policies. *Journal of Forest Science*, 70(6), 265–280.
3. Albe, V. (2013). Post-normal science education for sustainability. In R. Cohen (Ed.), *The Politics of Sustainability Education* (pp. 41–56). Routledge.
4. Birdsall, S. (2013). Measuring student green literacy: A context-based assessment approach. *Environmental Education Research*, 19(4), 451–467.
5. Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., & Yanda, P. (2007). Africa. In M. Parry (Ed.), *Climate Change 2007: Impacts, Adaptation and Vulnerability* (pp. 433–467). Cambridge University Press.
6. Demssie, Y. N., Biemans, H. J. A., Wesselink, R., & Mulder, M. (2020). Combining indigenous knowledge and modern education to foster sustainability competencies: Towards a set of learning design principles. *Sustainability*, 12(17), 6823.
7. Govender, N., & Stott, A. (2024). The role of Indigenous Knowledge Systems in STEM education for addressing the Sustainable Development Goals. *African Journal of Research in Mathematics, Science and Technology Education*, 28(1), 1–15.
8. Handayani, R. D., Wilujeng, I., & Prasetyo, Z. K. (2018). Elaborating indigenous knowledge in the science curriculum for the cultural sustainability. *Journal of Teacher Education for Sustainability*, 20(2), 74–88.
9. Hikuroa, D., Morgan, T. K. K. B., Durie, M., Henare, M., & Robust, T. T. (2011). Integration of indigenous knowledge and science. *The International Journal of Science in Society*, 2(2), 105–114.
10. Ihejirika, C. (2024). Harnessing African Indigenous Knowledge Systems for knowledge production: A redefinition of a culture-centric epistemology. *Journal of Contemporary Philosophical and Anthropological Studies*, 6(2), 45–62.
11. Iwuanyanwu, P. N., & Ogunniyi, M. B. (2024). Analysis of teachers' perspectives towards the use of IKS to improve STEM education for sustainable development. *African Journal of Research in Mathematics, Science and Technology Education*, 28(2), 120–138.
12. Matindike, F., & Ramdhany, V. (2024). Incorporating Indigenous knowledge perspectives in integrated STEM education: A systematic review. *Research in Science & Technological Education*, 42(3), 310–329
13. Moyo, S., & Kizito, R. (2014). Indigenising the curriculum: Voice and place in science education. *African Journal of Research in Mathematics, Science and Technology Education*, 18(2), 115–127.
14. Nyadzi, E., Ajayi, O. C., & Ludwig, F. (2021). Indigenous knowledge and climate change

adaptation in Africa: A systematic review. *CABI Reviews*, 2021(16), 1–15.

15. Ogegbo, A. A., & Ramnarain, U. (2024). A systematic review of pedagogical practices for integrating indigenous knowledge systems in science teaching. *African Journal of Research in Mathematics, Science and Technology Education*, 28(3), 343–361.
16. Okhueleigbe, O.A & Onuh, M.U. (2026). Extraterrestrial hydrometeorological phenomena and their communicative implications. Interpretive journalism perspective. *International Journal of Innovative Inventions in Social Science and Humanities*. 3(2), 71-180
17. Onwu, A. M., & Mufundirwa, A. (2020). Cultural relevance and meaning in learning science fields. *Journal of African Science Education*, 12(1), 89–102.
18. Onwu, A. M., & Mosimege, M. (2004). Indigenous knowledge systems and science and technology education: A dialogue. *African Journal of Research in Mathematics, Science and Technology Education*, 8(1), 1–12.
19. Oviedo-Berrocal, L. (2026). Integrating STEM education with indigenous ancestral knowledge, traditional knowledge, and intercultural contexts. *Journal of Intercultural STEM Education*, 4(1), 89–104.
20. Photo, P. (2026). Empowering rural STEM teachers in indigenous knowledge and technology integration: A qualitative longitudinal study. *African Journal of Research in Mathematics, Science and Technology Education*, 30(1), 12–25.
21. Seehawer, M., & Breidlid, A. (2025). Epistemological integration in education management: Dialogues between indigenous and Western epistemologies in Sub-Saharan Africa. In A. Rifai (Ed.), *Systematic Reviews in Educational Management* (pp. 78–93). Universitas Muhammadiyah Surakarta. Cited by: 11
22. Simonneaux, J., & Simonneaux, L. (2012). Educational configurations for dealing with socio-scientific sustainability issues. *Environmental Education Research*, 18(1), 75–87.
23. Sinthumule, N. I. (2023). Traditional ecological knowledge and its role in biodiversity conservation: A systematic review. *Frontiers in Environmental Science*, 11(1164900), 1–14.
24. Stuckey, M., Heering, P., Mamlok-Naaman, R., Hofstein, A., & Eilks, I. (2013). The philosophy of relevance in science education. *Studies in Science Education*, 49(1), 1–34.
25. Waheed, A. (2026). Elevating sustainability literacy (knowledge, attitudes, and behaviours) and sustainable practices through a sustainability-focused intervention. *Padua Research Archive*, 14(2), 201–218.
26. Wiid, N., & Ziervogel, G. (2012). Adapting to climate change in South Africa: The role of localized ecological education frameworks. *South African Geographical Journal*, 94(2), 154–168.
27. Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education*, 29(1), 145–185.
28. Zinyeka, G., Onwu, A. M., & Braun, M. (2016). A validation framework for integrating indigenous knowledge into school science. *African Journal of Research in Mathematics, Science and Technology Education*, 20(2), 103–114.