*International Journal of Ethnoscience and Technology in Education (IJETE)*
https://e-journal.undikma.ac.id/index.php/ijete/index

*September 2026 Vol. 3, No. 2*
*pp. 250-297*

# From Indigenous Knowledge to Higher-Order Learning: A Systematic Review of Ethnoscience, Contextual Learning Resources, and Knowledge Integration in African Education

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**Article Info**

**Article History**
Received: May 2026
Revised: August 2026
Published: September 2026

**Keywords**
Indigenous knowledge;
Ethnoscience;
Higher-order learning;
Contextual learning;
Knowledge integration;
African education

10.33394/ijete.v3i2.22510


**Abstract**

African Indigenous Knowledge has growing educational relevance, yet its relationship with higher-order learning remains fragmented across disciplines, pedagogies, and evidence types. This systematic thematic synthesis examined how Indigenous Knowledge is recontextualised through ethnoscience, transformed into contextual learning resources, integrated with formal disciplinary knowledge, and associated with higher-order learning in African education. Scopus-indexed peer-reviewed studies published between 2010 and 2026 were screened using a PRISMA-informed process, yielding 37 unique studies from 2,608 records. Evidence was organised into four themes: educational recontextualisation, contextual learning resources and pedagogies, higher-order learning outcomes, and enabling or constraining conditions. Findings indicate that Indigenous Knowledge supports meaningful learning when it moves beyond symbolic inclusion toward contextual integration, knowledge co-production, and epistemic participation. Contextual resources become educationally consequential when appropriately activated through dialogue, inquiry, cooperative learning, project-based learning, and cognitively demanding tasks. Direct evidence for metacognition, critical thinking, inferential reasoning, reflection, creative interpretation, and epistemic agency was promising but limited. The review proposes an Ethnoscience-to-Higher-Order Learning Framework in which cognitive outcomes depend on pedagogical mediation, cognitive demand, contextual resource design, and community participation.

**How to Cite:** Atubi, O. F., & Yazidi, R. E. (2026). From Indigenous Knowledge to Higher-Order Learning: A Systematic Review of Ethnoscience, Contextual Learning Resources, and Knowledge Integration in African Education. *International Journal of Ethnoscience and Technology in Education*, *3*(2), 250–297. https://doi.org/10.33394/ijete.v3i2.22510

## INTRODUCTION

African Indigenous Knowledge Systems (IKS) comprise culturally situated and intergenerational systems of observation, interpretation, experimentation, problem solving, and knowledge transmission that have developed through sustained relationships among communities, environments, livelihoods, technologies, languages, health practices, and social

institutions. Such knowledge is not simply a collection of inherited cultural facts. It encompasses ways of classifying phenomena, interpreting environmental change, evaluating risks, testing practical solutions, and transmitting expertise through participation, oral communication, apprenticeship, collective memory, and community practice. Across Africa, these knowledge traditions remain important intellectual and social resources, although their recognition within formal education has historically been constrained by epistemic hierarchies that privilege institutionally sanctioned disciplinary knowledge (Malapane et al., 2022; Seroto & Higgs, 2024).

The educational consequences of this separation are substantial. Colonial and postcolonial schooling systems have often maintained distinctions between knowledge recognised as legitimate within formal curricula and knowledge embedded in learners' families, communities, languages, environments, and everyday practices. Contemporary efforts toward curriculum decolonisation, culturally responsive pedagogy, contextualised instruction, place-based education, and Indigenous–scientific knowledge integration seek to address this divide. However, the inclusion of Indigenous Knowledge in formal education does not necessarily constitute meaningful epistemic integration. Indigenous practices can be incorporated merely as cultural illustrations that confirm pre-existing disciplinary concepts, leaving the underlying hierarchy of knowledge unchanged. More substantive integration requires attention to how Indigenous Knowledge is interpreted, who participates in its representation, how it is related to formal disciplinary knowledge, and what kinds of intellectual activity learners are expected to undertake with it (Seehawer, 2018; Seehawer & Breidlid, 2021).

Ethnoscience offers a useful analytical lens for examining this educational translation. In this review, ethnoscience is understood not as a synonym for Indigenous Knowledge, nor as a requirement that all included studies explicitly use the term, but as a translational perspective through which culturally embedded systems of observation, classification, explanation, experimentation, and practical reasoning can be interpreted as educationally meaningful knowledge. Ethnomathematics illustrates this process by showing how African games, kinship systems, divination practices, and other cultural activities may embody mathematical relationships and forms of reasoning that can be connected to formal mathematics (Chahine, 2020). Comparable processes occur when Indigenous chemical knowledge, fermentation practices, environmental observations, technologies, agricultural practices, or locally grounded scientific experiences are related to school science, STEM, teacher education, and vocational learning (Gumbo et al., 2021; Nyamupangedengu & Khupe, 2024; Tawanda & Mudau, 2024). The educational significance of ethnoscientific interpretation therefore lies in making the intellectual structures of culturally situated practices visible without reducing those practices to decorative curriculum content.

The central educational issue is consequently not whether African Indigenous Knowledge exists or whether it deserves recognition. A substantial body of scholarship already documents Indigenous Knowledge across agriculture, health, biodiversity,

environmental management, sustainability, climate adaptation, technology, and cultural life. The less resolved issue concerns pedagogical translation: how culturally embedded knowledge becomes educational content, how it is transformed into contextual learning resources, how Indigenous and formal disciplinary knowledge are brought into productive relationship, and how these processes are converted into intellectually demanding learning experiences. Existing studies provide important but fragmented evidence on individual parts of this process. Some focus on curriculum inclusion and decolonisation, while others examine Indigenous Knowledge as a contextual resource, community knowledge as prior knowledge, digital preservation, culturally responsive pedagogy, or specific learning outcomes. What remains insufficiently synthesised is the sequential relationship among Indigenous Knowledge, educational recontextualisation, contextual learning resources, knowledge-integration pedagogy, cognitively demanding engagement, and higher-order learning.

This unresolved relationship is particularly important because culturally relevant learning should not automatically be equated with higher-order cognition. Studies of Indigenous Knowledge integration have reported outcomes such as academic achievement, conceptual understanding, engagement, retention, relevance, and knowledge application (Gumbo et al., 2021; Ugwuoke et al., 2025). These outcomes are educationally meaningful, but they do not by themselves demonstrate critical thinking, metacognition, problem solving, creativity, inferential reasoning, evidence evaluation, or adaptive application. Other studies provide more direct cognitive evidence. Tawanda and Mudau (2024), for example, report positive effects of Indigenous Chemistry knowledge on metacognitive awareness, while Maledu and Ngobeni (2026) associate dialogic engagement with Sepedi folklore with inferential reasoning, evaluative understanding, and critical thinking. Such findings suggest a possible relationship between Indigenous Knowledge integration and higher-order learning, but the evidence remains heterogeneous in design, outcome measurement, context, and methodological strength.

Accordingly, this review uses higher-order learning as an umbrella analytical category for learning processes and outcomes that require learners to move beyond recall or reproduction toward analysis, evaluation, inference, problem solving, metacognitive regulation, creative production, reasoning, decision making, knowledge transfer, and adaptive application. This distinction is necessary because the cognitive potential of Indigenous Knowledge depends less on cultural content itself than on the intellectual activity organised around that content. A traditional practice may be memorised or critically examined; a community explanation may be repeated or compared with alternative explanations; and a local environmental problem may be described or investigated through evidence-based inquiry. The review therefore adopts a mediated rather than deterministic proposition. Indigenous Knowledge may contribute to higher-order learning when it is ethnoscientifically interpreted, represented through culturally grounded learning resources, integrated dialogically with formal disciplinary knowledge.

The need for such a synthesis is reinforced by the implementation conditions surrounding Indigenous Knowledge integration. Existing research identifies recurring constraints related to teacher preparation, pedagogical content knowledge, curriculum rigidity, assessment alignment, resource availability, institutional support, language, digital infrastructure, community participation, and epistemic authority (Mkhwebane, 2024; Mkhwebane et al., 2025; Fekumo & Phoshoko, 2026). These constraints indicate that meaningful integration cannot be understood solely as a classroom technique. It is more appropriately conceptualised as an educational process operating across pedagogical, curricular, institutional, community, and epistemic levels. Consequently, examining cognitive outcomes without analysing the conditions that enable or constrain knowledge integration risks attributing effects to Indigenous Knowledge that may actually depend on teacher mediation, resource design, curriculum structures, and the quality of community participation.

Against this background, the present review makes three interrelated contributions. First, it distinguishes the curricular inclusion of Indigenous Knowledge from meaningful epistemic participation, thereby shifting attention from whether Indigenous Knowledge is present in education to how it participates in knowledge construction. Second, it differentiates direct evidence of higher-order cognition from indirect outcomes such as achievement, retention, engagement, and conceptual understanding, thereby reducing the risk of overstating cognitive effects. Third, it synthesises these relationships into an Ethnoscience-to-Higher-Order Learning Framework that conceptualises higher-order learning as a mediated outcome of ethnoscientific interpretation, contextual resource development, knowledge-integration pedagogy, and cognitively demanding learner engagement. The framework is not proposed as a universal causal model, but as an integrative theoretical architecture that can be examined against available evidence and adapted to diverse African educational contexts.

The review focuses primarily on African school, vocational, teacher-education, and higher-education settings, particularly science, STEM, mathematics, environmental and sustainability education, literacy, and culturally responsive education. Supporting interdisciplinary studies are retained where they clarify mechanisms of knowledge transmission, contextualisation, digitalisation, community participation, knowledge co-production, or learning-resource development. Within this scope, the review examines how Indigenous Knowledge is educationally recontextualised, how it is represented through contextual learning resources, how it is integrated with formal disciplinary knowledge, what evidence exists regarding higher-order learning, and which conditions facilitate or constrain meaningful implementation.

## Research Questions

The review addresses the following research questions:

1. RQ1: How are Indigenous Knowledge and ethnoscience conceptualised and incorporated into African educational contexts?

2. RQ2: What pedagogical approaches and contextual learning resources are used to integrate Indigenous and scientific knowledge in African education?
3. RQ3: What evidence exists concerning the relationship between Indigenous Knowledge integration and higher-order learning, particularly critical thinking, inquiry, creativity, problem solving, metacognition, reasoning, and adaptive application?
4. RQ4: What pedagogical, epistemological, institutional, cultural, and resource-related factors facilitate or constrain the transformation of Indigenous Knowledge into higher-order learning opportunities?

## THEORETICAL BACKGROUND

### Indigenous Knowledge, Ethnoscience, and Knowledge Integration

Indigenous Knowledge is culturally situated, cumulative, experiential, intergenerational, and relational. It develops through sustained interactions among people, place, language, livelihood, environment, social institutions, and cultural practice. Its educational significance therefore extends beyond the transmission of factual content. Indigenous Knowledge also encompasses locally developed systems of observation, classification, interpretation, explanation, experimentation, decision making, and practical reasoning. Because such knowledge is embedded within particular social, cultural, and environmental relationships, its educational meaning can be altered when practices are separated from the contexts in which they are produced, validated, and transmitted (Malapane et al., 2022; Seroto & Higgs, 2024).

Ethnoscience provides an analytical perspective for examining the intellectual structures embedded within culturally situated knowledge. Rather than treating Indigenous practices merely as cultural examples, ethnoscientific interpretation considers how communities classify phenomena, recognise patterns, develop explanations, evaluate observations, test practical solutions, and connect knowledge to particular environments and social purposes. In educational contexts, this perspective makes it possible to interpret culturally embedded knowledge in relation to formal disciplinary concepts without assuming that Indigenous Knowledge and formal science constitute identical epistemic systems. Chahine (2020), for example, demonstrates how African games, kinship relations, divination practices, and other cultural activities can reveal mathematical structures and forms of reasoning within ethnomathematical contexts. Comparable processes of educational recontextualisation have been identified in the interpretation of Karanga beer-brewing practices in relation to Biology and fermentation and in the use of Indigenous Chemistry to contextualise formal Chemistry learning (Nyamupangedengu & Khupe, 2024; Tawanda & Mudau, 2024).

The relationship between culturally situated knowledge and school science can also be understood as a process of negotiating epistemic and cultural boundaries. Aikenhead and Jegede (1999) conceptualise movement between learners' everyday life-worlds and school science as a form of cultural border crossing, particularly when the assumptions and explanatory systems of these worlds differ. Similarly, science education can provide

opportunities for learners to negotiate relationships between Indigenous science and Western modern science rather than requiring one knowledge tradition to be displaced by the other (Snively & Corsiglia, 2001). These perspectives are particularly relevant to ethnoscientific education because they draw attention not only to what knowledge is taught but also to how learners navigate different systems of meaning, evidence, and explanation.

The educational relationship between Indigenous and disciplinary knowledge can take qualitatively different forms. Assimilation occurs when Indigenous Knowledge becomes educationally acceptable primarily after being translated into dominant disciplinary categories. Inclusion goes somewhat further by introducing Indigenous examples into formal curricula, but may leave existing epistemic hierarchies substantially unchanged. Contextual integration deliberately establishes relationships between Indigenous and disciplinary knowledge to support interpretation and learning. Knowledge co-production involves more active participation among learners, educators, researchers, and community knowledge holders in the construction of educational knowledge. Epistemic pluralism represents a more dialogic relationship in which distinct knowledge traditions can retain their histories, purposes, cultural characteristics, and validation practices while entering into critical and educationally productive interaction.

These distinctions matter because knowledge integration involves more than combining two bodies of information. It also concerns how differently situated knowledge systems are articulated and how epistemic authority is distributed within the educational relationship. The integration of knowledge systems in African contexts has consequently been conceptualised as a problem of articulation involving educational institutions, communities, policy structures, and different traditions of knowledge production (Odora Hoppers, 2002). Seehawer and Breidlid (2021) similarly conceptualise meaningful integration as a dialogue between epistemologies in which neither formal science nor Indigenous Knowledge is automatically treated as the sole legitimate intellectual reference point.

Such a position does not imply that all knowledge claims should be considered interchangeable. Differences in purpose, evidence, context, explanation, validation, and applicability remain important and can themselves become objects of educational inquiry. Recognition of multiple knowledge ecologies therefore requires attention to both epistemic diversity and the power relationships through which particular forms of knowledge acquire institutional legitimacy (Medvecky et al., 2023).

Ubuntu-oriented perspectives add a relational dimension to this understanding. Relationality, interdependence, participation, collective responsibility, and shared knowledge practices are central to Ubuntu-informed approaches to education (Mkosi et al., 2023; Seneque et al., 2023). Mkosi et al. (2023) specifically position Ubuntu values as relevant to the integration of African Indigenous Knowledge into teaching and learning. From this perspective, meaningful knowledge integration involves relationships among learners, teachers, communities, knowledge holders, and disciplinary traditions rather than the transfer of isolated cultural content into formal curricula.

## Coloniality, Decolonisation, and Epistemic Participation

The contemporary position of Indigenous Knowledge in African education cannot be separated from the historical organisation of knowledge under colonial schooling. Colonial education privileged European languages, disciplinary traditions, institutional structures, and epistemic classifications while frequently locating African knowledge practices outside the boundaries of legitimate formal education. Postcolonial educational systems consequently inherited not only particular curricular content but also assumptions about which forms of knowledge could be authorised, documented, assessed, and transmitted through schools and universities (Seroto & Higgs, 2024).

Decolonisation in education therefore involves more than increasing the visibility of Indigenous cultural content. It also concerns epistemic participation and authority. A curriculum may formally acknowledge Indigenous Knowledge while continuing to position it as supplementary, anecdotal, or subordinate to established disciplinary knowledge. Such inclusion may increase cultural representation without fundamentally altering how knowledge is selected, interpreted, validated, or assessed. The broader challenge is therefore to move beyond representational inclusion toward educational arrangements in which Indigenous Knowledge can participate meaningfully in processes of inquiry, interpretation, curriculum construction, and knowledge production (Odora Hoppers, 2002; Seehawer & Breidlid, 2021).

Seehawer (2018) illustrates this issue in South African science education, where teachers may support the integration of Indigenous and Western knowledge while lacking sufficient local knowledge, pedagogical strategies, or appropriate curriculum materials. One response is to recognise learners, parents, elders, healers, and other members of local communities as legitimate educational knowledge resources. Such participation changes the relationship between schools and communities by moving beyond learning about community knowledge toward engaging with communities as participants in knowledge construction.

Related developments are evident in contextualised, place-based, culturally responsive, and Africa-centred education. Indigenous environmental knowledge has been positioned alongside Western scientific knowledge in climate-change education, while heritage practices and locally situated knowledge have been connected with problem-posing science and sustainability education (Ngcoza, 2019; Tanyanyiwa, 2019). Mademabe et al. (2022) similarly demonstrate how community knowledge can be related to mathematical geometry within technical and vocational education. These examples indicate that contextualisation can create educational spaces in which learners encounter formal disciplinary ideas through knowledge practices connected to lived experience.

Epistemic participation also extends beyond classroom pedagogy. Curriculum policy, assessment arrangements, teacher education, learning resources, institutional recognition, and relationships with communities influence whether Indigenous Knowledge functions as an active educational resource or remains primarily symbolic. Formal curriculum recognition does not necessarily result in substantive integration when teacher agency, professional

preparation, assessment, and institutional structures remain poorly aligned with that recognition (Fekumo & Phoshoko, 2026; Kangethe, 2025).

The theoretical significance of decolonisation for this review therefore lies in the distinction between presence and participation. The presence of Indigenous Knowledge indicates that culturally situated content has entered formal education, whereas epistemic participation concerns the extent to which Indigenous knowledge traditions and knowledge holders contribute to interpretation, dialogue, inquiry, validation, and educational decision making. This distinction provides an important basis for evaluating whether knowledge integration represents substantive educational transformation or primarily symbolic inclusion.

### Epistemic Legitimacy, Knowledge Integration, and Higher-Order Learning

The integration of Indigenous and disciplinary knowledge raises several theoretical tensions. The first concerns epistemic legitimacy. Treating Indigenous Knowledge and formal science as mutually exclusive may reproduce a binary in which formal science is associated with universal rationality while Indigenous Knowledge is reduced to culture or tradition. The opposite position, in which all knowledge claims are treated as equivalent, creates a different problem because it obscures differences in purpose, evidence, validation, historical development, and context. Epistemic pluralism provides an alternative by recognising the legitimacy of multiple knowledge traditions while preserving opportunities for critical examination, comparison, and dialogue (Medvecky et al., 2023; Seehawer & Breidlid, 2021).

This tension has long been recognised in cross-cultural science education. Snively and Corsiglia (2001) argue that defining Western modern science as the only legitimate form of science can function as a curricular gatekeeping mechanism that marginalises locally developed Indigenous knowledge. Aikenhead and Jegede (1999), from a related perspective, show that encounters between learners' life-worlds and school science can involve cultural and cognitive negotiations. These perspectives support an understanding of knowledge integration as an educational encounter between differently situated systems of meaning rather than as a simple transfer of Indigenous examples into conventional scientific instruction.

A second tension concerns decontextualisation. Indigenous Knowledge is frequently connected with particular languages, landscapes, social relationships, cultural practices, custodians, and community responsibilities. Educational transformation may make such knowledge more accessible while simultaneously separating it from the social and epistemic relationships through which it acquires meaning. This tension is particularly visible in documentation and digitalisation. Digital preservation can increase the accessibility of Indigenous Knowledge but also raises concerns about intellectual ownership, cultural authority, and inappropriate appropriation (Kugara & Mokgoatšana, 2022; Mdhluli et al., 2021).

Masenya (2022) similarly argues that the preservation and decolonisation of Indigenous Knowledge require meaningful involvement of knowledge holders and communities rather

than predominantly external institutional control. Contextualisation should therefore not be understood merely as attaching local examples to established disciplinary content. It also involves cultural integrity, intellectual ownership, language, community authority, and decisions about how, by whom, and for what purposes knowledge may be represented.

A third theoretical tension concerns cognitive outcomes. The presence of Indigenous Knowledge within a learning environment does not itself establish that higher-order learning has occurred. Cultural familiarity may increase relevance, participation, or engagement without necessarily requiring learners to analyse, evaluate, infer, create, reflect, or solve problems. Likewise, academic achievement, conceptual understanding, or retention may indicate successful learning while providing insufficient evidence that higher-order cognitive processes have been activated. Positive achievement and retention outcomes have been reported in culturally contextualised Physics and ICT learning, but such findings are conceptually distinct from direct evidence of critical thinking, metacognition, or evaluative reasoning (Gumbo et al., 2021; Ugwuoke et al., 2025).

More explicit cognitive evidence becomes visible when learners are required to undertake intellectually demanding activity. Tawanda and Mudau (2024) associate Indigenous Chemistry integration with metacognitive awareness, whereas Maledu and Ngobeni (2026) identify inferential reasoning, evaluative understanding, and critical thinking through dialogic engagement with Sepedi folklore. The distinction between these findings and general achievement outcomes suggests that the cognitive significance of Indigenous Knowledge depends substantially on what learners are required to do with culturally situated knowledge.

In this review, higher-order learning is used as an analytical umbrella rather than as a single psychometric construct. It encompasses learning processes and outcomes involving analysis, evaluation, inference, inquiry, problem solving, metacognitive regulation, creative production, reasoning, decision making, knowledge transfer, and adaptive application. The constituent constructs retain their conceptual distinctions but share an emphasis on cognitive activity that extends beyond recall, recognition, and routine reproduction. Classical conceptualisations of higher-order thinking similarly emphasise relationships among critical thinking, problem solving, decision making, and cognitive complexity, while revised cognitive taxonomies distinguish analysing, evaluating, and creating from lower-complexity cognitive processes (Anderson & Krathwohl, 2001; Lewis & Smith, 1993).

Indigenous Knowledge can therefore provide a potentially productive context for higher-order learning when learners are required to compare explanations, investigate phenomena, interpret evidence, evaluate claims, construct solutions, reflect on different forms of knowledge, make reasoned decisions, or apply ideas to authentic problems. The theoretical question is consequently not whether Indigenous Knowledge inherently produces higher-order learning, but under what educational conditions culturally situated knowledge becomes a resource for cognitively demanding activity.

The relationship between Indigenous Knowledge integration and higher-order learning is therefore conceptualised as mediated rather than deterministic. Cognitive outcomes depend on how Indigenous Knowledge is interpreted, represented, connected with disciplinary knowledge, and pedagogically activated. This distinction provides the theoretical rationale for separating direct evidence of higher-order cognition from achievement, engagement, retention, and other indirect learning outcomes in the subsequent synthesis.

## Conceptual Basis of the Ethnoscience-to-Higher-Order Learning Framework

The preceding perspectives provide the conceptual basis for the Ethnoscience-to-Higher-Order Learning Framework examined through this review. The framework begins from the premise that Indigenous Knowledge constitutes culturally situated epistemic resources rather than pre-packaged instructional content. Educational use therefore requires attention to the intellectual structures, cultural meanings, contextual purposes, and relationships through which such knowledge is produced and transmitted. Ethnoscientific interpretation provides one means of identifying systems of observation, classification, explanation, experimentation, and practical reasoning within culturally embedded practices (Chahine, 2020; Nyamupangedengu & Khupe, 2024).

Ethnoscientific interpretation is conceptually important because it occupies an intermediate position between cultural recognition and educational recontextualisation. Without interpretation, Indigenous Knowledge may remain disconnected from formal curriculum structures. However, interpretation also creates the risk of reducing culturally situated knowledge to disciplinary concepts that are already privileged by formal education. Meaningful interpretation must therefore retain attention to cultural context while making relevant relationships with disciplinary knowledge educationally accessible. Cross-cultural science education similarly suggests that movement between community knowledge and school knowledge involves negotiation across epistemic and cultural boundaries rather than simple conceptual substitution (Aikenhead & Jegede, 1999; Snively & Corsiglia, 2001).

A second element concerns contextual learning resources. Educationally interpreted Indigenous Knowledge must be represented in forms through which learners can encounter, investigate, discuss, or apply it. Such resources may include oral narratives, folklore, Indigenous games, cultural artefacts, environmental phenomena, community practices, Indigenous technologies, locally produced materials, digital repositories, visual representations, projects, or community expertise. The theoretical significance of these resources lies not simply in their cultural origin but in their capacity to connect formal learning with culturally and environmentally situated experience (Adeyeye & Mason, 2020; O'Donoghue et al., 2024).

Resource representation alone, however, does not determine the quality of learning. The third element is knowledge-integration pedagogy. Contextual resources may function only as illustrations unless teaching establishes intellectually productive relationships between Indigenous and disciplinary knowledge. Dialogue, inquiry, problem posing, cooperative learning, project-based activity, comparison of explanations, evidence evaluation, and

community participation can provide pedagogical mechanisms through which learners engage with multiple knowledge traditions. Seehawer and Breidlid (2021) emphasise epistemological dialogue in such relationships, while the broader concept of articulation highlights the need to negotiate rather than merely juxtapose different systems of knowledge (Odora Hoppers, 2002).

The depth of integration therefore varies according to the epistemic role assigned to Indigenous Knowledge. It may be used as an example of an already established disciplinary concept, as a contextual entry point into formal learning, as a knowledge tradition to be compared critically with disciplinary explanations, or as a resource within collaborative processes of knowledge construction. These differences are theoretically important because they shape both the distribution of epistemic authority and the cognitive activity available to learners.

Cognitively demanding engagement constitutes the immediate conceptual connection between knowledge integration and higher-order learning. Cultural contextualisation alone is not a cognitive mechanism. Higher-order learning becomes more plausible when pedagogical activities require interpretation, analysis, inference, evaluation, inquiry, reflection, problem solving, creative production, decision making, knowledge transfer, or adaptation. The same Indigenous practice or learning resource may therefore generate substantially different educational outcomes depending on the intellectual demands embedded within the task.

This proposition also prevents the framework from attributing cognitive effects directly to Indigenous Knowledge. Higher-order learning is not conceptualised as an intrinsic property of culturally relevant content. Rather, Indigenous Knowledge can provide epistemically rich and contextually meaningful material around which cognitively demanding pedagogy may be organised. The distinction is essential for interpreting empirical studies because achievement, engagement, cultural relevance, and higher-order cognition represent related but non-equivalent educational outcomes.

The proposed pathway operates within broader pedagogical, curricular, institutional, community, and epistemic conditions. Teacher knowledge, pedagogical content knowledge, professional development, curriculum flexibility, assessment alignment, learning-resource availability, institutional recognition, language, digital infrastructure, community participation, and knowledge governance may enable or constrain how the pathway operates in particular settings (Fekumo & Phoshoko, 2026; Mkhwebane, 2024; Mkhwebane et al., 2025).

These conditions are conceptualised as enabling or constraining conditions rather than as statistically specified moderating variables. Their influence may occur at multiple stages. Limited teacher knowledge may constrain the identification and interpretation of Indigenous Knowledge; inadequate resources may restrict educational representation; rigid curriculum or assessment arrangements may limit opportunities for dialogic integration; and weak community participation may reduce cultural authenticity and epistemic legitimacy. Conversely, teacher agency, professional development, flexible curriculum structures,

appropriate resources, community co-design, and institutional recognition may create more favourable conditions for substantive integration.

Community participation is especially important because it affects both the cultural integrity of educational resources and the distribution of epistemic authority. Indigenous knowledge holders should not be understood solely as sources from whom culturally relevant information can be extracted. Their participation can contribute to knowledge interpretation, validation, curriculum development, decisions concerning appropriate representation, and governance of how culturally situated knowledge is used in educational contexts (Gqibitole, 2026; Mbah & Fonchingong, 2019).

## METHODS

### Review Design and Reporting Approach

This study employed a Scopus-based systematic thematic synthesis to examine how African Indigenous Knowledge is recontextualised for education, transformed into contextual learning resources, integrated with formal disciplinary knowledge, and associated with higher-order learning. A systematic approach was used for literature identification, screening, eligibility assessment, and evidence organisation, while thematic and narrative synthesis was adopted because the included literature was heterogeneous in educational setting, disciplinary domain, research design, pedagogical approach, Indigenous Knowledge domain, and learning outcome.

The review was designed to address four interconnected analytical areas corresponding to the research questions: the educational conceptualisation and recontextualisation of Indigenous Knowledge and ethnoscience; contextual learning resources and pedagogical approaches for knowledge integration; evidence concerning higher-order learning; and the conditions that facilitate or constrain sustainable integration. The study-selection process was documented using a PRISMA-informed flow structure, as presented in Figure 1.

The review focused principally on African school education, vocational education, teacher education, and higher education, particularly within science, STEM, mathematics, literacy, environmental and sustainability education, and culturally responsive education. Interdisciplinary publications were retained selectively when they provided evidence relevant to educational knowledge transmission, contextualisation, community participation, knowledge co-production, digitalisation, preservation, or learning-resource development.

### Database Search and Search Strategy

Scopus was used as the bibliographic database for this review. The database was selected because of its multidisciplinary coverage across education, social sciences, science, technology, environmental studies, and related fields relevant to Indigenous Knowledge research. The search covered publications from 2010 to 2026, with the final Scopus corpus prepared on 1 May 2026.

The search architecture was organised around four conceptual domains. The first represented Indigenous Knowledge and ethnoscience and included terms such as

"Indigenous Knowledge," "Indigenous Knowledge Systems," "indigenous science," "traditional knowledge," "local knowledge," "ethnoscience," and "traditional ecological knowledge." The second represented African educational contexts and included terms such as "Africa," "Sub-Saharan Africa," "education," "school," "learner," "teacher," "curriculum," "STEM," "science education," "environmental education," and "higher education." The third represented contextualisation and knowledge integration and included "learning resources," "instructional materials," "contextual learning," "culturally responsive pedagogy," "place-based education," "knowledge integration," and "knowledge co-production." The fourth represented higher-order learning and related cognitive processes, including "higher-order thinking," "critical thinking," "problem solving," creativity, inquiry, reasoning, metacognition, "adaptive expertise," "knowledge transfer," and "decision making."

Synonymous terms within each conceptual domain were combined using OR, whereas major conceptual domains were connected using AND. The search was structured around the Scopus TITLE-ABS-KEY fields to prioritise records in which the relevant concepts occurred in the title, abstract, or author keywords. Complementary combinations of the conceptual domains were necessary because requiring all constructs to occur simultaneously could exclude relevant studies investigating mechanisms such as contextualisation, inquiry, metacognition, or knowledge integration without explicitly using the terminology of higher-order learning.

The archived project materials preserve the bibliographic corpus and the principal study-selection counts but do not contain the original executable Scopus search-history file. The following expression is therefore reported as a representative formulation of the search architecture rather than as a verbatim reconstruction of the historical query: *TITLE-ABS-KEY (("ethnoscience" OR "indigenous science" OR "indigenous knowledge" OR "indigenous knowledge systems" OR "traditional knowledge" OR "local knowledge") AND (Africa* OR "Sub-Saharan Africa") AND (("learning resources" OR "contextual learning" OR "knowledge integration") OR ("higher-order thinking" OR "critical thinking" OR "problem solving" OR creativity OR inquiry OR reasoning)))*

The initial Scopus search identified 2,608 records. Predefined database-level filtering removed 2,006 records, leaving 602 records for title and abstract screening. No duplicate records were identified at this stage. The archived materials preserve the number of records removed through these Scopus filters but do not retain a sufficiently detailed field-by-field historical filter log to permit exact retrospective reconstruction. This limitation is reported explicitly rather than inferring filter settings that cannot be verified.

## Eligibility Criteria

Records were considered eligible when they were Scopus-indexed peer-reviewed journal publications published within the defined period and substantively addressed an African country, an African region, Sub-Saharan Africa, or a clearly identifiable African educational context. Eligible publications also needed to engage substantively with Indigenous Knowledge, Indigenous Knowledge Systems, ethnoscience, traditional

knowledge, local knowledge, Indigenous science, or relationships between Indigenous and formal disciplinary knowledge.

For inclusion in the focused educational synthesis, publications were required to demonstrate identifiable relevance to one or more of the following areas: teaching and learning, pedagogy, curriculum, teacher education, educational assessment, contextual learning resources, knowledge integration, knowledge transmission, learner cognition, or higher-order learning.

Publications were excluded when Indigenous Knowledge was incidental rather than substantive; when they addressed domain-specific Indigenous Knowledge without an identifiable process of educational recontextualisation; when they lacked sufficient African-context relevance; when they did not align with the review questions or the knowledge-integration and higher-order-learning focus; or when available methodological and outcome information was insufficient for meaningful synthesis. Publications concerned exclusively with ethnobotany, ethnopharmacology, medicine, agriculture, biodiversity, conservation, or natural-resource management were therefore not retained unless a clear educational, pedagogical, learning-resource, or knowledge-transmission dimension was identifiable.

Two evidence roles were distinguished. Core educational evidence consisted of studies directly addressing learners, teachers, curricula, educational institutions, classroom practices, interventions, assessment, learning resources, or cognitive outcomes. Supporting interdisciplinary evidence was retained when it contributed to understanding mechanisms of contextualisation, community participation, knowledge preservation, co-production, digitisation, cultural transmission, or the transformation of community knowledge into educational resources. Supporting publications were used primarily for conceptual and contextual interpretation and were not treated as equivalent to direct educational evidence when evaluating learning outcomes.

### Screening and Study Selection

The identification and selection process is summarised in Figure 1. The initial Scopus search produced 2,608 records. Predefined Scopus filters excluded 2,006 records, resulting in 602 records entering title and abstract screening. No duplicate records or records removed for other reasons were recorded before screening.

Title and abstract screening excluded 451 records that did not satisfy the conceptual and educational boundaries of the review. This stage produced 151 reports for which full texts were sought. Eight reports could not be retrieved, leaving 143 reports for eligibility assessment.

Full-text eligibility assessment resulted in the exclusion of 106 reports. The principal reasons were absence of identifiable educational, pedagogical, or knowledge-transfer relevance (n = 43); domain-specific Indigenous Knowledge without educational recontextualisation (n = 24); lack of alignment with the review questions or the knowledge-integration and higher-order-learning focus (n = 15); insufficient African-context relevance (n = 8); Indigenous Knowledge being incidental rather than substantive (n = 7); insufficient

methodological or outcome information for synthesis (n = 5); and overlapping or companion evidence (n = 4). Where publications provided substantially overlapping or companion evidence, the report offering the most relevant information for the analytical focus was retained to avoid double counting substantially equivalent evidence.

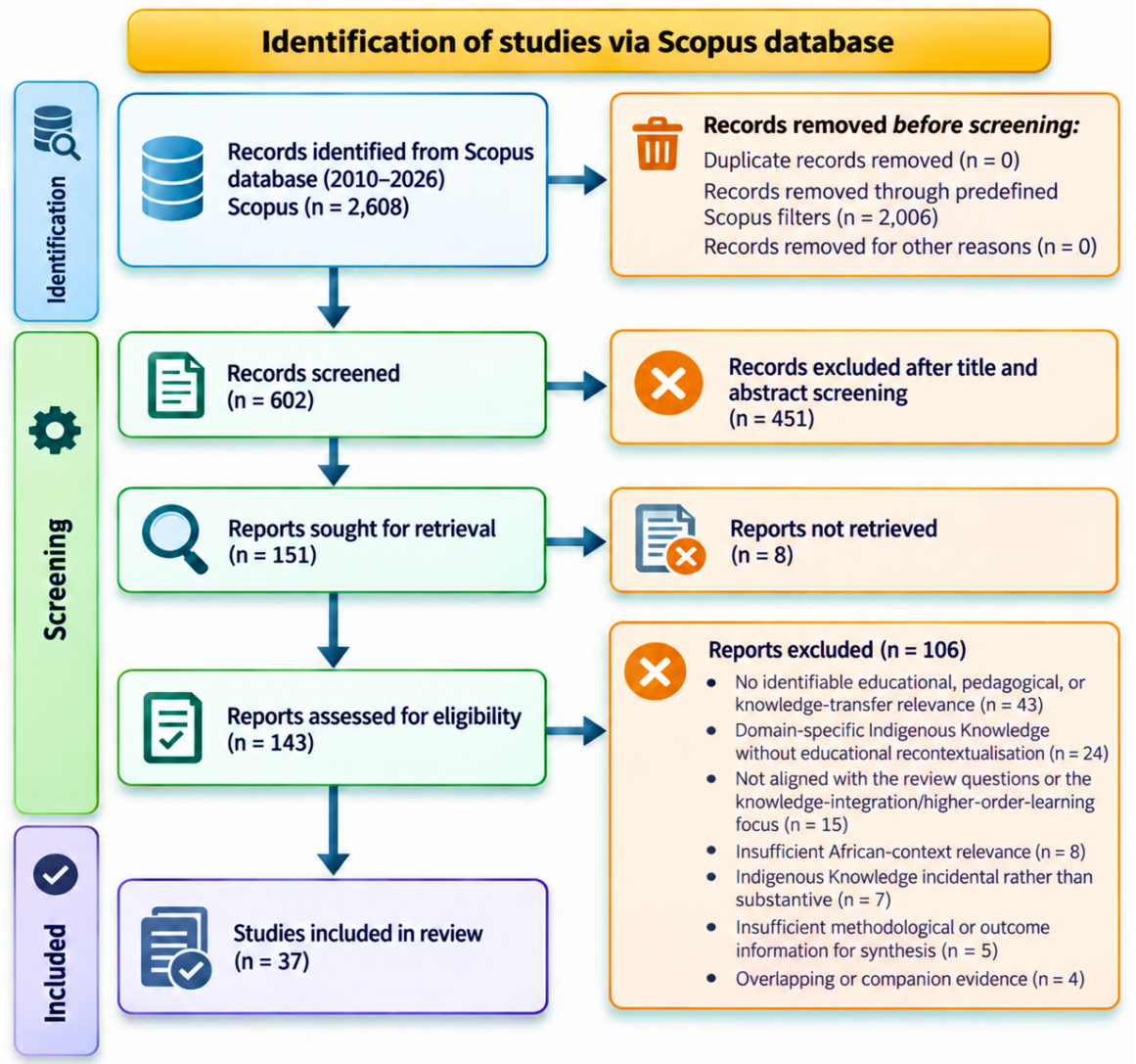


**Figure 1.** PRISMA-informed flow diagram of study identification, screening, eligibility assessment, and inclusion

The screening and eligibility process resulted in 37 unique studies included in the focused synthesis. Additional Scopus-indexed publications from the wider corpus were used selectively for theoretical, historical, and contextual framing but were not counted as additional studies within the 37-study focused evidence base.

## Data Extraction and Thematic Coding

Information extracted from the included studies covered country or regional context, educational level, disciplinary domain, Indigenous Knowledge domain, contextual learning-resource type, pedagogical approach, mechanism of Indigenous and formal knowledge

integration, reported educational or cognitive outcome, implementation barriers, enabling conditions, and type of evidence concerning higher-order learning.

The extraction framework was aligned with the four research questions. The first analytical theme examined the forms of Indigenous Knowledge represented in educational contexts and the processes through which culturally situated knowledge was interpreted or recontextualised as teachable content. The second examined contextual learning resources and pedagogical mechanisms through which Indigenous and disciplinary knowledge were connected. The third examined the nature and strength of evidence concerning higher-order learning. The fourth examined pedagogical, curricular, institutional, cultural, community, resource-related, and epistemic conditions that enabled or constrained meaningful integration.

The coding therefore served both descriptive and interpretive purposes. Descriptively, it mapped the educational contexts, knowledge domains, resources, pedagogies, and reported outcomes represented in the literature. Analytically, it examined how the literature connected ethnoscientific interpretation, contextual resource development, knowledge-integration pedagogy, cognitively demanding engagement, and higher-order learning.

### Evidence Appraisal

Scopus indexing was treated as a bibliographic eligibility criterion rather than as evidence of methodological quality. The focused evidence base included qualitative, quantitative, mixed-method, participatory action research, quasi-experimental, review, and conceptual studies. These designs were not treated as methodologically equivalent because they provided different forms and strengths of evidence.

A formal item-level methodological quality score was not assigned. Although the review protocol considered the Mixed Methods Appraisal Tool for empirical studies, the archived evidence available for the present synthesis did not contain a complete full-text appraisal record that would allow defensible retrospective reconstruction of study-level MMAT scores. Assigning such scores from abstracts or incomplete records would create an unjustified appearance of methodological precision. Evidence was therefore appraised using a design-sensitive approach that considered study design, the nature of the outcome assessed, the source of evidence, and identifiable methodological limitations.

Particular care was taken in interpreting claims concerning higher-order learning. Academic achievement, engagement, retention, cultural relevance, or conceptual understanding were not treated automatically as evidence of higher-order cognition. The review instead distinguished three evidence categories.

Direct evidence referred to empirical studies that explicitly examined one or more higher-order cognitive constructs through identifiable quantitative, qualitative, or mixed-method evidence. Relevant constructs included critical thinking, metacognition, inferential or evaluative reasoning, problem solving, decision making, creative production, epistemic agency, reflection, and closely related cognitive processes.

Indirect evidence referred to studies reporting academic achievement, conceptual understanding, retention, engagement, contextual application, knowledge use, or related outcomes that may support meaningful learning but do not independently demonstrate higher-order cognition.

Conceptual evidence referred to theoretical, review-based, or emerging work proposing plausible relationships between Indigenous Knowledge integration and critical thinking, inquiry, creativity, adaptive expertise, reasoning, decision making, or related higher-order processes without directly assessing such outcomes empirically.

### Thematic and Narrative Synthesis

Meta-analysis was not undertaken because the evidence base varied substantially in study design, setting, disciplinary area, Indigenous Knowledge domain, pedagogical intervention, resource type, and outcome measurement. The evidence was therefore synthesised thematically and narratively.

Within each research question, studies were compared for areas of convergence, divergence, methodological strength, contextual specificity, and reported limitations. Particular attention was given to distinguishing what the evidence demonstrated directly from what could only be inferred or proposed conceptually.

The integrative synthesis examined whether the literature supported a mediated relationship in which culturally situated Indigenous Knowledge is interpreted as educationally meaningful content, represented through contextual learning resources, connected with formal disciplinary knowledge through appropriate pedagogical mechanisms, and activated through cognitively demanding learner engagement. Higher-order learning was consequently treated as a conditional and pedagogically mediated outcome rather than as an automatic consequence of including Indigenous Knowledge in formal education.

## RESULTS AND DISCUSSION

The focused synthesis comprised 37 unique studies representing diverse African educational settings, disciplinary domains, Indigenous Knowledge traditions, pedagogical approaches, and methodological designs. The evidence was organised into four interrelated themes corresponding directly to the research questions: the educational recontextualisation of Indigenous Knowledge; contextual learning resources and pedagogical mechanisms for knowledge integration; evidence concerning higher-order learning; and the pedagogical, curricular, institutional, community, and epistemic conditions that enable or constrain meaningful integration. The studies were sufficiently heterogeneous in educational level, disciplinary emphasis, research design, intervention characteristics, and outcome measurement that statistical aggregation would have obscured rather than clarified the underlying patterns. The analysis therefore concentrated on recurring mechanisms, areas of convergence and divergence, and differences in evidentiary strength. Particular attention was given to two distinctions established in the Theoretical Background and Methods: the

distinction between the curricular presence of Indigenous Knowledge and meaningful epistemic participation, and the distinction between direct evidence of higher-order cognition and outcomes that provide only indirect or conceptual support. These distinctions provide the analytical basis for interpreting the four evidence tables and the integrative framework developed from the synthesis.

## From Indigenous Knowledge to Ethnoscientific Educational Content

The first theme addresses RQ1 by examining how culturally situated African knowledge is conceptualised and transformed into educationally meaningful content. The included studies demonstrate that Indigenous Knowledge enters education through multiple disciplinary pathways rather than through a single ethnoscientific model. Mathematics studies identify culturally embedded patterns and reasoning within games, kinship relations, and symbolic practices, while science-oriented studies reinterpret Indigenous Chemistry, fermentation, environmental observation, technologies, and community practices in relation to formal disciplinary concepts. Other studies locate Indigenous Knowledge within climate education, sustainability education, vocational mathematics, teacher education, and community-based curriculum design. Table 1 summarises these patterns and demonstrates that educational recontextualisation involves different levels of transformation. In some cases, Indigenous Knowledge functions primarily as culturally relevant content that makes formal concepts more familiar. In others, it becomes a substantive epistemic resource through which learners, teachers, and community members participate in interpretation, comparison, inquiry, and knowledge production. The evidence therefore suggests that the central issue is not simply whether Indigenous Knowledge enters the curriculum, but the intellectual and epistemic role that it is allowed to perform once it becomes part of formal education.

**Table 1.** Forms and educational recontextualisation of Indigenous Knowledge in African education

| Study | Context | Indigenous Knowledge domain | Educational recontextualisation | Scientific or academic connection | Key finding | Limitation |
|---|---|---|---|---|---|---|
| Chahine (2020) | African cultures; mathematics | Games, kinship, divination | Ethnomathematical practices interpreted as curriculum resources | Formal mathematical reasoning | Cultural practices can reveal mathematical structures relevant to African learning contexts | Conceptual; educational effects not directly tested |
| Tawanda and Mudau (2024) | Zimbabwe; pre-service Chemistry education | Indigenous Chemistry | Indigenous knowledge used to contextualise Chemistry learning | Chemistry concepts and metacognition | Indigenous Chemistry contributed positively to metacognitive engagement | Small purposive sample |

| Study | Context | Indigenous Knowledge domain | Educational recontextualisation | Scientific or academic connection | Key finding | Limitation |
|---|---|---|---|---|---|---|
| Gumbo et al. (2021) | School Physics | African Indigenous Knowledge materials | Culturally grounded materials integrated with formal science teaching | Gravitational acceleration | Improved achievement and contextua relevance | Focused on one Physics concept |
| Nyamupangedengu and Khupe (2024) | Southern Africa; Biology/STEM | Karanga beer brewing | Heritage practice interpreted as teachable scientific content | Biology and fermentation | Demonstrates potential to humanise and contextualise STEM learning | Limited controlled learning-outcome evidence |
| O'Donoghue et al (2024) | Southern Africa; STEAM teacher education | Indigenous technologies | Heritage practices used in co-developed lesson resources | STEAM and sustainability | Strong potential for culturally grounded curriculum-resource development | Teacher heritage knowledge and time constraints |
| Seehawer (2018) | South Africa; school science | Community Indigenous Knowledge | Participatory integration of Indigenous and Western knowledge | School science | Integration becomes more substantive when communities function as knowledge resources | Limited curriculum materials and teacher Indigenous Knowledge |
| Mademabe et al. (2022) | South Africa; TVET mathematics | Community knowledge | Indigenous Knowledge embedded in practical assessment | Geometry | Connects abstract mathematics with lived and occupational experience | Small, context-specific study |
| Tanyanyiwa (2019) | Zimbabwe; secondary climate education | Environmental and weather knowledge | Indigenous Knowledge positioned alongside Western science | Climate science | Supports contextualised climate-chang education | Limited direct learner-outcome evidence |
| Sotero et al. (2020 | School education; includes African evidence | Local and scientific knowledge | Review of articulation between local and scientific knowledge | Science and interdisciplinary education | Teacher preparation and closer school-community relationships are important | Heterogeneous multi-country review |

| Study | Context | Indigenous Knowledge domain | Educational recontextualisation | Scientific or academic connection | Key finding | Limitation |
|---|---|---|---|---|---|---|
| Ngcoza (2019) | South Africa; science and sustainability education | Heritage practices | Heritage knowledge incorporated through problem-posing education | Science and sustainability | Reconnects formal science with learners' lived worlds | Primarily theoretical |
| Mkhwebane (2024) | South Africa; Grades 10–12 Life Sciences | Biological Indigenous Knowledge | Integration across Life Sciences topics | Life Sciences | Teachers valu integration bu implementatic n remains limited | Five teachers; preparation and pedagogical-content-knowledge limitations |
| Latip et al. (2024) | Science education; international review including African studies | Multiple local and Indigenous knowledge domains | Knowledge domains mapped to science-learning contexts | Climate, ecology, medicine, astronomy, and related areas | Demonstrates broad contextual-learning potential | African evidence forms only part of the review |

Ethnomathematics provides one of the clearest illustrations of how educational recontextualisation can reveal intellectual structures that are not immediately visible when a cultural practice is treated only as tradition. Chahine (2020) demonstrates that African games, kinship relations, divination systems, and related cultural practices can embody mathematical relationships and forms of reasoning that may be connected with formal mathematical learning. Comparable mechanisms are evident in science education, although the disciplinary translation takes different forms. Karanga beer brewing, for example, has been interpreted in relation to biological and fermentation processes, while Indigenous Chemistry has been used to contextualise formal Chemistry learning (Nyamupangedengu & Khupe, 2024; Tawanda & Mudau, 2024). Gumbo et al. (2021) similarly integrate African Indigenous Knowledge materials with formal Physics instruction concerning gravitational acceleration. Across these examples, culturally situated practices are not educationally valuable merely because they are familiar to learners. Their value emerges when the practices are interpreted as containing systems of observation, classification, explanation, measurement, experimentation, or practical reasoning that can enter into meaningful dialogue with formal disciplinary knowledge.

The findings also show that ethnoscientific interpretation can vary considerably in epistemic depth. At a relatively limited level, Indigenous Knowledge may be used as an illustration of a disciplinary concept that has already been defined through conventional curriculum structures. Such use may increase familiarity and cultural relevance without

altering the epistemic organisation of the lesson. At a deeper level, Indigenous Knowledge can become a resource for inquiry, comparison, explanation, and curriculum construction. Teacher education and vocational education provide examples of this deeper recontextualisation. Indigenous technologies and heritage practices have been used collaboratively in the development of STEAM learning resources, while practical assessment in vocational mathematics has connected community knowledge with geometric concepts (Mademabe et al., 2022; O'Donoghue et al., 2024). These forms of engagement are educationally significant because Indigenous Knowledge contributes to the design and organisation of learning rather than appearing only after formal disciplinary concepts have been established. The distinction supports the theoretical proposition that meaningful integration requires attention to the epistemic role assigned to culturally situated knowledge.

Community participation further differentiates substantive recontextualisation from simple curricular inclusion. Seehawer (2018) demonstrates that learners, parents, elders, healers, and other community members can function as legitimate educational knowledge resources when teachers lack sufficient Indigenous Knowledge or culturally grounded materials. Ngcoza (2019) similarly links re-appropriated heritage practices with problem-posing science education and sustainability learning, suggesting that culturally situated knowledge can contribute to curriculum development through participatory relationships rather than exclusively through academic translation. More recent studies support this interpretation. Learners' Indigenous and informal experiences can function as prior knowledge within contextualised science instruction, while teachers can act as cultural brokers who connect local agricultural practices with ecosystem science through inquiry, storytelling, and culturally relevant representations (Okeke & Ramaila, 2025; Singh-Pillay & Madlala, 2026). These studies indicate that recontextualisation becomes more epistemically substantive when communities contribute not merely examples but interpretations, meanings, practices, and criteria of relevance. The process therefore concerns both pedagogical translation and the distribution of authority over how Indigenous Knowledge is represented.

Taken together, the evidence supports a continuum of Indigenous–scientific knowledge integration rather than a single form of curricular incorporation. Assimilation represents situations in which Indigenous Knowledge is accepted primarily after translation into dominant disciplinary categories, while inclusion introduces culturally specific examples without necessarily altering the epistemic hierarchy of the curriculum. Contextual integration establishes more deliberate relationships between Indigenous and disciplinary knowledge, whereas knowledge co-production enables learners, teachers, researchers, and community knowledge holders to contribute actively to interpretation and curriculum construction. Epistemic pluralism extends this relationship by recognising that different knowledge traditions may retain distinct histories, purposes, evidence practices, and validation criteria while still participating in critical educational dialogue. Figure 2 represents these distinctions analytically rather than prescriptively. The findings do not demonstrate that every

educational activity should move toward the same endpoint. Instead, the continuum is useful because it separates cultural visibility from epistemic participation and makes visible why the presence of Indigenous content in formal education should not automatically be interpreted as evidence of substantive knowledge integration.

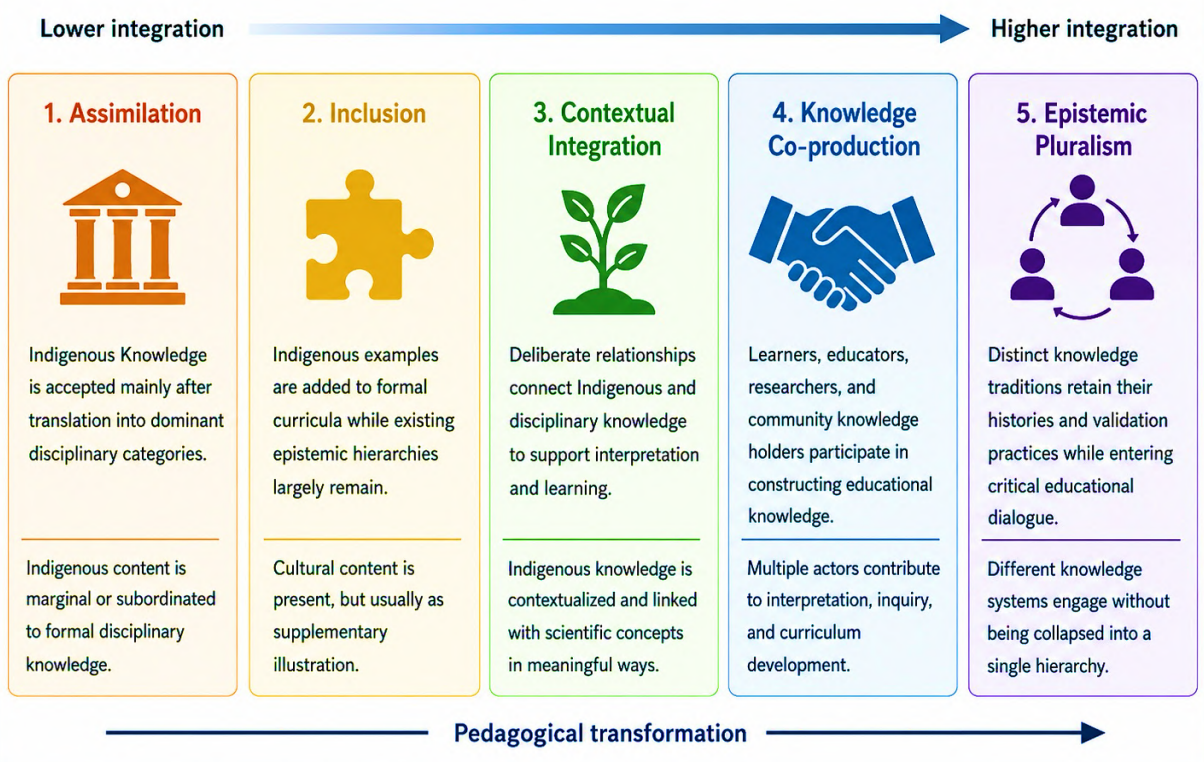


**Figure 2.** Indigenous–Scientific Knowledge Integration Continuum

The first theme also exposes an important limitation in the evidence base. Many studies are qualitative, conceptual, exploratory, or strongly dependent on particular cultural and disciplinary contexts, while relatively few compare alternative models of recontextualisation using common criteria. Consequently, the literature provides substantial evidence that African Indigenous Knowledge can become educationally meaningful across science, mathematics, sustainability, teacher education, and vocational learning, but much weaker evidence that a single model of ethnoscientific recontextualisation can be generalised across communities or countries. This limitation should not be interpreted simply as a deficiency in methodological standardisation. Contextual specificity is partly intrinsic to Indigenous Knowledge because meaning is frequently connected with language, place, social relations, local environments, and community practice. A model that successfully recontextualises Karanga brewing, Sepedi folklore, or a particular community technology cannot be assumed to retain the same meaning when transplanted into an unrelated setting. The evidence therefore supports adaptable principles of interpretation and participation rather than a universal template for converting Indigenous Knowledge into curriculum content.

## Contextual Learning Resources and Pedagogical Mechanisms for Knowledge Integration

The second theme addresses RQ2 by examining the representational forms through which recontextualised Indigenous Knowledge becomes available for formal learning and the

pedagogical mechanisms through which Indigenous and disciplinary knowledge are brought into educational relationship. The evidence demonstrates that contextual learning resources are materially and symbolically diverse. They include folklore, proverbs, riddles, Indigenous games, cultural symbols, community narratives, local environmental practices, Indigenous technologies, project materials, culturally relevant analogies, digital repositories, open educational resources, interactive technologies, and learners' own community knowledge. Table 2 shows that resource type alone does not explain educational outcomes because similar culturally grounded materials can support very different forms of learning depending on how teachers organise classroom activity around them. This finding is central to the review because it shifts attention away from the assumption that culturally authentic resources possess inherent pedagogical power. Instead, their educational significance emerges through the interaction between representation, instructional design, learner participation, disciplinary connection, and cognitive demand.

**Table 2.** Contextual learning resources and knowledge-integration pedagogies

| Study | Contextual learning resource | Pedagogical approach | Knowledge-integration mechanism | Reported outcome | Implementation issue |
|---|---|---|---|---|---|
| Mkhwebane et al. (2025) | Interactive whiteboards and Indigenous Knowledge materials | Technology-supported culturally responsive teaching | Digital Indigenous Knowledge connected with cellular-respiration concepts | Teachers perceived improved engagement and understanding | Reliable resources, professional development, and technical constraints |
| Adeyeye and Mason (2020) | Open educational resources and digital technologies | Open and distance educational practice | Digital preservation, access, and educational integration | Opportunities to revitalise African Indigenous Knowledge | Colonial, structural, and digital constraints |
| Maledu and Ngobeni (2026) | Folktales, proverbs, and riddles | Dialogic folklore pedagogy | Cultural narratives interpreted, discussed, and evaluated | Inferential and evaluative reasoning; critical thinking | Curriculum alignment, community collaboration, and teacher development |
| Sefoka and Chuene (2025) | Learners' Indigenous Knowledge | Cooperative learning | Collaborative dialogue between Indigenous Knowledge and Life Sciences | Participation, comprehension, and critical or independent expression | Teacher and curriculum support |
| Ugwuoke et al. (2025) | Cultural analogies and scenarios | Culturo-Techno- | Integration of culture, technology, | Higher long-term ICT retention | Need for culturally appropriate |

| Study | Contextual learning resource | Pedagogical approach | Knowledge-integration mechanism | Reported outcome | Implementation issue |
|---|---|---|---|---|---|
| | | Contextual Approach | and learning context | | resources and teacher competence |
| Armah et al. (2026) | Afrocyberlibrary | Culturo-Techno-Contextual Approach | Digital African resources integrated with cybersecurity learning | Higher achievement and contextual understanding | Resource scalability; explicit higher-order cognition not measured |
| Adetunji and Ade-Ibijola (2026) | AI-adapted African games | Gamified and AI-supported learning | Indigenous game structures translated into training simulations | Potential for strategic reasoning and decision making | Requires stronger empirical outcome testing |
| Boakye-Yiadom et al. (2025) | Adinkra symbols and project resources | Project-based learning | Interpretation combined with creative production | Improved Indigenous Knowledge understanding and cultural analysis | Community partnerships require strengthening |
| Jiyane (2026) | Community storytelling | Participatory storytelling pedagogy | Story-based interaction and co-design | Cognitive, emotional, and social development | Practitioner preparation |
| Nxumalo and Mncube (2018) | isiZulu Indigenous games | Ubuntu-oriented pedagogy | Embodied participation and collective learning | Cultural values and collective learning | Educational efficacy insufficiently investigated |
| van Wyk (2014) | Afrocentric Indigenous Knowledge | Afrocentric-Indigenous pedagogy | Curriculum structured around culturally meaningful knowledge | Inclusive conceptual model | Conceptual rather than empirically tested |
| Seehawer and Breidlid (2021) | Community knowledge and multiple epistemologies | Dialogue between epistemologies | Critical comparison and contextual combination of knowledge traditions | Context-relevant and sustainability-oriented learning | Requires sophisticated teacher mediation |

The strongest pattern across Table 2 is that contextual learning resources become educationally consequential when pedagogy requires learners to perform intellectual work with them. Maledu and Ngobeni (2026), for example, do not merely expose learners to Sepedi folktales, riddles, and proverbs as culturally familiar reading materials. Their dialogic

pedagogy requires interpretation, inference, evaluation, and discussion, allowing the cultural resource to become a medium for higher-level literacy activity. A related mechanism appears in cooperative Life Sciences learning, where learners' Indigenous Knowledge is incorporated into collaborative discussion and disciplinary interpretation rather than functioning solely as a teacher-provided illustration (Sefoka & Chuene, 2025). Project-based learning with Ghanaian Adinkra symbols also demonstrates this relationship because students engage in cultural interpretation and creative production rather than simply identifying symbolic meanings (Boakye-Yiadom et al., 2025). These examples support the argument that contextual resources should be evaluated according to the intellectual activity they enable. Cultural familiarity can increase relevance, but relevance becomes cognitively productive only when instructional design creates opportunities for interpretation, comparison, construction, inquiry, or application.

Digitalisation represents a second major pattern in the evidence and substantially expands the possible forms of contextual learning resources. Open educational resources, digital repositories, institutional documentation systems, and digital libraries can increase access to Indigenous Knowledge that might otherwise remain geographically or institutionally restricted (Adeyeye & Mason, 2020; Buthelezi et al., 2024; Mdhluli et al., 2021). Classroom technologies extend this potential by enabling Indigenous materials to be incorporated into disciplinary instruction through interactive representations. Mkhwebane et al. (2025), for example, report teacher perspectives on using interactive whiteboards to support the integration of Indigenous Knowledge within cellular-respiration teaching. More recent approaches combine cultural context, digital technology, and formal curriculum through the Culturo-Techno-Contextual Approach. Positive outcomes have been reported in ICT retention and cybersecurity learning, while a wider review of experimental applications suggests generally favourable patterns for meaningful STEM learning and academic achievement (Armah et al., 2026; Oladejo et al., 2025; Ugwuoke et al., 2025). These findings demonstrate considerable educational potential, but they also require careful interpretation because improved achievement or retention does not independently demonstrate higher-order cognition.

The evidence therefore challenges technologically deterministic interpretations of contextual learning. Digital platforms, artificial intelligence, repositories, and interactive technologies may broaden access or provide new representational possibilities, but technology itself does not determine the quality of knowledge integration. A digital repository can preserve Indigenous Knowledge while leaving learners cognitively passive, just as a conventional narrative can support sophisticated reasoning when embedded in dialogic inquiry. The same caution applies to AI-supported adaptation of African games. Adetunji and Ade-Ibijola (2026) propose potentially valuable applications involving strategic decision making, resource management, and risk assessment, but such outcomes require stronger empirical testing before they can be treated as established cognitive effects. The significance of technology therefore depends on how it interacts with pedagogy, cultural meaning,

disciplinary purpose, and learner activity. This finding reinforces the broader distinction between contextual resources and contextual pedagogy. Resources provide access, representation, or experience, whereas pedagogy determines whether learners simply encounter the resource or use it as a basis for interpretation, inquiry, comparison, problem solving, and knowledge construction.

The benefits of digitalisation must also be considered alongside epistemic and ethical risks. Indigenous Knowledge is often connected with language, place, custodianship, community responsibilities, and culturally specific forms of transmission. Digitisation can increase accessibility while simultaneously separating knowledge from the social relationships through which its meaning is maintained. Studies of Indigenous Knowledge preservation therefore raise concerns about intellectual theft, linguistic distortion, inappropriate appropriation, and weak community control over digital representations (Kugara & Mokgoatšana, 2022; Mdhluli et al., 2021). Similar tensions arise when artificial intelligence is used to document or transform culturally situated knowledge because technical adaptation may simplify dynamic cultural practices into static categories or simulations. These concerns indicate that resource development is not merely a technical design problem. It also involves decisions about ownership, validation, cultural integrity, and authority. Educational innovation should therefore consider whether communities participate in deciding what knowledge is documented, how it is represented, and under what conditions it can be accessed or adapted for formal learning.

Taken together, the second theme supports a clear analytical distinction between contextual learning resources and knowledge-integration pedagogy. Culturally grounded resources make Indigenous Knowledge available within formal learning, but their educational significance depends on how they are pedagogically activated. Narratives, artefacts, games, environmental practices, digital resources, community expertise, and culturally relevant analogies can all support meaningful learning, yet none guarantees analysis, inquiry, creativity, or problem solving. Teachers must establish intellectually productive relationships among cultural resources, disciplinary knowledge, learner experience, and explicit learning tasks. This conclusion also explains why teacher competence and curriculum flexibility repeatedly appear as implementation conditions. Place-based and culturally contextualised approaches can remain fragmented when teachers lack sufficient preparation or when centralised curriculum structures restrict contextual inquiry (Nwigwe, 2026). The evidence therefore suggests that effective integration is achieved not by selecting an Indigenous resource alone, but by designing learning environments in which culturally situated knowledge becomes a basis for disciplinary dialogue, active investigation, interpretation, and purposeful application.

### Indigenous Knowledge Integration and Higher-Order Learning

The third theme addresses RQ3 and constitutes the cognitive core of the review because it asks whether Indigenous Knowledge integration is actually associated with higher-order learning rather than only with cultural relevance or general educational improvement. The

Methods distinguished direct, indirect, and conceptual evidence to prevent different types of learning outcomes from being treated as equivalent. Direct evidence refers to empirical studies that explicitly examine higher-order cognitive processes, including critical thinking, metacognition, inferential or evaluative reasoning, reflection, creative production, or epistemic agency. Indirect evidence includes outcomes such as achievement, conceptual understanding, retention, engagement, or contextual application that may be related to higher-order learning but do not independently establish it. Conceptual evidence proposes plausible cognitive mechanisms without directly assessing them empirically. Table 3 applies this classification consistently across representative studies. The resulting pattern is important because the literature contains many positive educational outcomes, but a substantially smaller group of studies provides direct evidence that learners actually engage in identifiable higher-order cognitive processes.

**Table 3.** Evidence linking Indigenous Knowledge integration with higher-order learning

| Study | Context or intervention | Higher-order or cognitive construct | Assessment or evidence | Evidence type | Interpretation and limitation |
|---|---|---|---|---|---|
| Tawanda and Mudau (2024) | Zimbabwe; Indigenous Chemistry learning | Metacognition; problem-solving orientation | Focus groups and paper-and-pen assessment | Direct | Positive metacognitive influence; small purposive sample |
| Maledu and Ngobeni (2026) | South Africa; folklore pedagogy | Critical thinking; inferential and evaluative reasoning | Interviews, observations, and learner documents | Direct | Explicit higher-order cognitive evidence; no experimental comparator |
| Gumbo et al. (2021) | School Physics; culturally grounded Indigenous Knowledge materials | Applied understanding | Learner performance analysed through ANCOVA | Indirect | Stronger evidence for achievement than for higher-order cognition |
| Armah et al. (2026) | Higher education; contextual pedagogy and Afrocyberlibrary | Contextual and applied understanding | Quasi-experimental and qualitative evidence | Indirect | Comparative learning evidence; no explicit higher-order instrument |
| Lentz et al. (2026) | South Africa; teacher education | Epistemic agency and reflection | Multi-cycle action research | Direct | Explicit cognitively relevant processes; limited contextual scale |
| Boakye-Yiadom et al. (2025) | Ghana; Adinkra project learning | Interpretation and creative application | Interviews, observations, and student projects | Direct | Creative and interpretive activity evident; no standardised creativity measure |

| Study | Context or intervention | Higher-order or cognitive construct | Assessment or evidence | Evidence type | Interpretation and limitation |
|---|---|---|---|---|---|
| Sefoka and Chuene (2025) | Grade 10 Life Sciences | Critical and independent thinking | Observation and learner documents | Direct | Explicit qualitative cognitive evidence; very small sample |
| Mademabe et al. (2022) | TVET geometry | Contextual problem solving and application | Focus-group evidence | Indirect | Application evident, but higher-order cognition not independently operationalised |
| Age (2025) | Sub-Saharan Africa; conceptual analysis | Higher-order mathematical thinking | Conceptual synthesis | Conceptual | Proposed mechanism; no primary empirical intervention |
| Dyantyi (2026) | South African university | Real-world problem solving | Interviews | Indirect | Contextual application identified; limited direct cognitive assessment |
| Adetunji and Ade-Ibijola (2026) | African small-business education | Decision making, risk assessment, and resource management | Framework evaluation | Conceptual | Plausible cognitive mechanisms; controlled learning effects not established |
| Seehawer and Breidlid (2021) | Sub-Saharan Africa; dialogue between epistemologies | Critical engagement and contextual application | Participatory and theoretical synthesis | Conceptual | Strong conceptual rationale; higher-order constructs not directly assessed as outcomes |

The direct evidence, although limited in quantity, provides the strongest empirical support for a relationship between Indigenous Knowledge integration and higher-order learning. Tawanda and Mudau (2024) associate Indigenous Chemistry learning with metacognitive awareness, indicating that culturally grounded disciplinary engagement can influence how learners monitor and regulate their own thinking. Maledu and Ngobeni (2026) provide another relatively clear example by identifying inferential reasoning, evaluative understanding, and critical thinking within dialogic engagement with Sepedi folklore. Other studies provide qualitative evidence of critical and independent expression in cooperative Life Sciences learning, creative and interpretive engagement in Adinkra-based projects, and epistemic agency and reflection in Africanising teacher education (Boakye-Yiadom et al., 2025; Lentz et al., 2026; Sefoka & Chuene, 2025). These studies use different methodologies and should not be treated as methodologically equivalent, but they share an important feature: the higher-order process itself is visible in the evidence rather than being inferred solely from

improved performance. This distinction justifies their classification as direct evidence even when standardised cognitive tests are not used.

The broader group of indirect studies demonstrates why this distinction is necessary. Gumbo et al. (2021) report improved learner performance following the integration of African Indigenous Knowledge materials into Physics instruction, and Armah et al. (2026) report stronger achievement and contextual understanding in technology-supported cybersecurity learning. Ugwuoke et al. (2025) similarly identify improved long-term ICT retention through culturally contextualised pedagogy. These findings are educationally valuable because they demonstrate that culturally grounded approaches can support formal learning outcomes, but they do not identify the cognitive processes responsible for those outcomes. Achievement may involve analysis or reasoning, yet a total achievement score cannot establish whether those processes were activated unless they are explicitly assessed. Retention may support later transfer, but it is not equivalent to transfer. Engagement may create favourable conditions for inquiry, but it does not demonstrate that inquiry occurred. The evidence therefore supports meaningful educational benefits while simultaneously requiring restraint in claiming higher-order cognitive effects.

Conceptual studies broaden the range of possible higher-order outcomes but also reveal a substantial empirical gap. Performance-based assessment within Ubuntu-oriented mathematics education has been proposed as a mechanism for higher-order engagement, while AI-supported adaptation of African games has been associated conceptually with decision making, risk assessment, strategic reasoning, and resource management (Adetunji & Ade-Ibijola, 2026; Age, 2025). Seehawer and Breidlid (2021) provide a strong theoretical rationale for critical engagement through dialogue between epistemologies, particularly when learners examine differences among knowledge claims, explanatory systems, and contextual purposes. Such work is important because it identifies mechanisms that can be tested in future research, but conceptual plausibility should not be treated as equivalent to demonstrated learning effects. The gap between theoretical possibility and empirical measurement is especially visible for creativity, adaptive expertise, knowledge transfer, decision making, and sustained problem solving. These constructs are frequently invoked in discussions of culturally responsive and Indigenous Knowledge pedagogy, but comparatively few studies operationalise them explicitly or assess whether learning gains persist across contexts and time.

The evidence architecture consequently reveals a clear asymmetry between the breadth of educational promise and the strength of direct cognitive evidence. The largest body of research supports outcomes such as achievement, engagement, retention, conceptual understanding, relevance, and contextual application. A narrower group provides explicit evidence concerning critical thinking, metacognition, inferential reasoning, reflection, creative production, and epistemic agency.

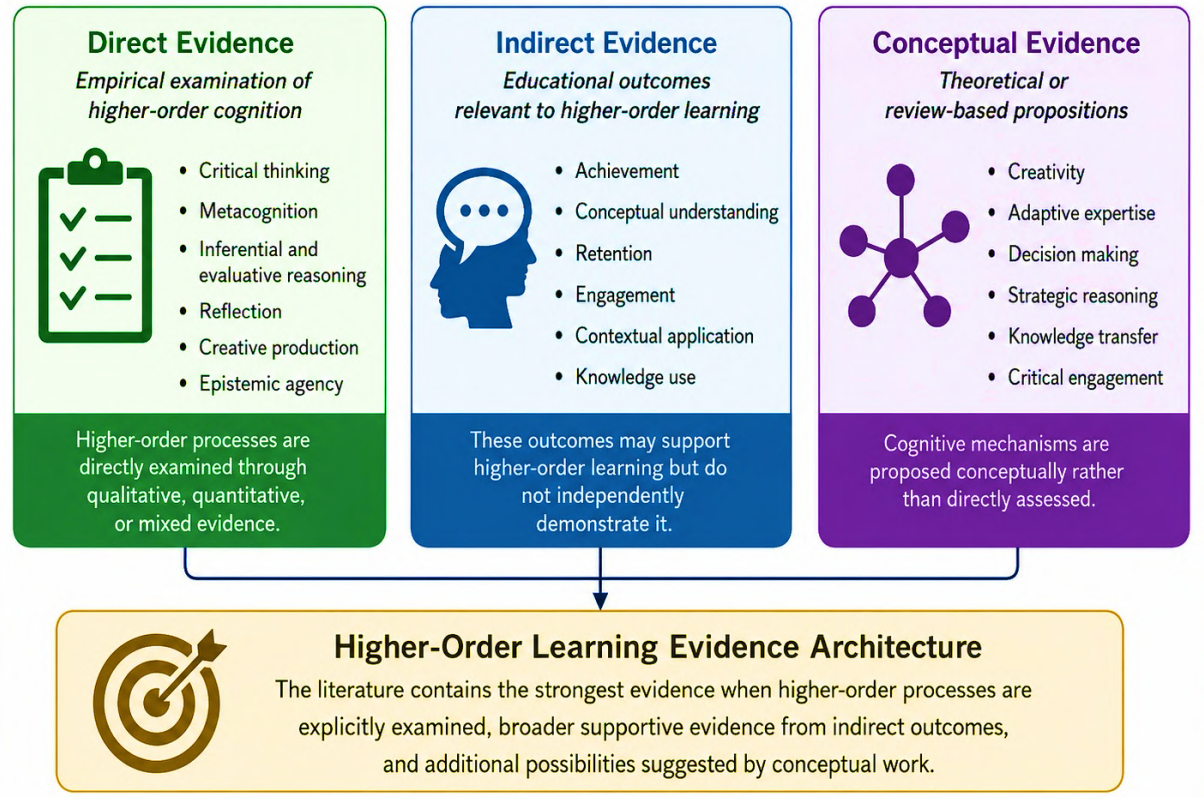


**Figure 3.** Higher-Order Learning Evidence Architecture.

Conceptual studies propose an even broader set of possible outcomes than either empirical category currently establishes. This pattern does not invalidate claims that Indigenous Knowledge can support higher-order learning. Rather, it specifies the evidentiary conditions under which such claims are defensible. Broader science-education research supports similar caution because inquiry, creativity, critical thinking, technology-supported learning, and cultural responsiveness remain inconsistently operationalised across educational studies (Masalimova et al., 2024). The measurement challenge is therefore partly a wider problem in education research, although it becomes especially important here because culturally responsive interventions are sometimes credited with cognitive benefits on the basis of engagement or achievement measures that were not designed to assess higher-order cognition directly.

Despite this evidentiary limitation, a theoretically coherent pattern appears across the direct studies. Higher-order cognitive activity is most visible when culturally situated knowledge is accompanied by tasks that require learners to interpret, compare, infer, evaluate, reflect, construct explanations, or create products. This suggests that Indigenous Knowledge does not operate as a cognitive intervention independently of pedagogy. Instead, it provides epistemically rich and contextually meaningful material around which demanding intellectual activity can be organised. The same Indigenous resource could therefore support simple recall in one instructional setting and critical reasoning in another, depending on the task structure, teacher mediation, learner participation, and disciplinary purpose. This interpretation is consistent with the mediated proposition established in the Theoretical

Background. The relationship between Indigenous Knowledge integration and higher-order learning becomes plausible when ethnoscientific interpretation, contextual resource design, knowledge integration, and cognitive demand operate in combination. The evidence therefore supports conditional rather than universal claims concerning cognitive benefit.

The most defensible answer to RQ3 is consequently more qualified than a simple positive or negative conclusion. The reviewed literature provides direct evidence that Indigenous Knowledge integration can support metacognition, critical and inferential reasoning, reflection, epistemic agency, and creative interpretation under particular pedagogical conditions. It also provides a larger body of indirect evidence showing improvements in achievement, conceptual understanding, retention, engagement, and contextual application. However, the existing evidence does not justify the claim that the inclusion of Indigenous Knowledge automatically produces higher-order learning. Cultural contextualisation creates an opportunity for cognitively meaningful engagement, but pedagogy determines whether this opportunity becomes activated. This conclusion is important because it avoids both underestimating Indigenous Knowledge as academically peripheral and overstating its cognitive effects on the basis of outcomes that were not designed to measure higher-order cognition. It also establishes a clear basis for the integrative framework developed later in this section.

### Enabling Conditions, Barriers, and Sustainable Integration

The fourth theme addresses RQ4 by examining why Indigenous Knowledge integration becomes substantive and sustainable in some contexts but remains symbolic, fragmented, or difficult to implement in others. The evidence demonstrates that meaningful integration cannot be explained at the classroom level alone because barriers and enabling conditions operate across teacher preparation, curriculum, assessment, institutional infrastructure, technology, language, community relationships, and epistemic authority. Table 4 summarises these factors and shows that many barriers occur simultaneously. A teacher may value Indigenous Knowledge yet lack pedagogical content knowledge, reliable resources, or sufficient curriculum flexibility. A school may possess digital infrastructure but lack culturally validated materials or community participation. A university may formally endorse curriculum decolonisation while retaining institutional structures that continue to privilege Western disciplinary traditions. The findings therefore support an ecosystem perspective in which sustainable integration depends on relationships among pedagogical capability, structural alignment, knowledge infrastructure, community participation, and epistemic governance rather than on any single intervention or policy commitment.

**Table 4.** Barriers, enablers, and pathways for sustainable Indigenous Knowledge integration

| Study | Level | Major barrier | Key enabler | Implication for integration | Future direction |
|---|---|---|---|---|---|
| Mkhwebane (2024) | Classroom and curriculum | Limited training and support; weak pedagogical | Targeted professional development, | Stronger teacher mediation enables | Develop teacher competence and |

| Study | Level | Major barrier | Key enabler | Implication for integration | Future direction |
|---|---|---|---|---|---|
| | | content knowledge; uncertain or negative orientations | resources, and ICT support | substantive integration | contextual-resource design |
| Mkhwebane et al. (2025) | Classroom and resources | Scarcity of reliable Indigenous Knowledge resources; technical and professional-development constraints | Digital resources and institutional support | Enables technology-supported contextualisation | Strengthen capacity and resource allocation |
| Fekumo and Phoshoko (2026) | Policy and curriculum | Symbolic or uneven integration; policy-practice gap | Teacher agency and policy-assessment alignment | Supports substantive rather than tokenistic integration | Align curriculum, assessment, and teacher preparation |
| Mkosi et al. (2023) | Teacher development | Limited concrete classroom strategies and professional development | Continuous Ubuntu-informed professional development | Strengthens pedagogical capability | Develop and empirically test concrete teaching strategies |
| O'Donoghue et al. (2024) | Teacher education | Heritage-knowledge and time constraints | Community co-design | Supports more authentic STEAM resources | Strengthen heritage knowledge within teacher preparation |
| Seehawer (2018) | Classroom and curriculum | Limited Indigenous Knowledge within curriculum and scarce materials | Communities as knowledge resources | Supports epistemic dialogue and contextual learning | Strengthen resources and school-community partnerships |
| Kangethe (2025) | Higher education | Institutional and structural constraints | Curriculum indigenisation and dialogic approaches | Strengthens Indigenous Knowledge legitimacy | Mainstream context-sensitive indigenisation |
| Buttner et al. (2026) | Higher education curriculum | Dominance of Western theoretical traditions | Real-world Indigenous contexts | Supports applied and evaluative reasoning | Expand contextually grounded curriculum design |
| Buthelezi et al. (2024) | Institutional infrastructure | Fragmented documentation and access | Institutional repositories and | Improves educational resource availability | Institutionalise Indigenous Knowledge documentation |

| Study | Level | Major barrier | Key enabler | Implication for integration | Future direction |
|---|---|---|---|---|---|
| | | | dissemination systems | | |
| Mdhluli et al. (2021) | Knowledge infrastructure | Knowledge loss and intellectual theft | Community-sensitive digital libraries | Supports ethical preservation and access | Protect community ownership, rights, and benefits |
| Kugara and Mokgoatšana (2022) | Cultural and digital | Language, methodological, financial, and political constraints | Context-preserving multi-stakeholder digitisation | Supports greater cultural authenticity | Preserve linguistic and cultural integrity |
| Mbah and Fonchingong (2019) | University and community | Weak reciprocal university-community relationships | Socio-ecological community partnerships | Provides authentic and complex learning contexts | Institutionalise reciprocal knowledge relationships |
| Medvecky et al. (2023) | Epistemic and institutional | Formal science treated as the singular legitimate paradigm | Participatory multiple-knowledge processes | Supports critical epistemic comparison | Address power relationships as well as content |
| Gqibitole (2026) | Curriculum and governance | Indigenous knowledge holders peripheral to curriculum transformation | Direct participation in curriculum co-design | Promotes shared epistemic authority | Establish people-driven curriculum mechanisms |

Teacher capacity is the most consistently reported classroom-level constraint. Life Sciences teachers report insufficient preparation, limited pedagogical content knowledge, inadequate professional development, weak institutional support, and difficulty accessing culturally reliable Indigenous Knowledge resources (Mkhwebane, 2024; Mkhwebane et al., 2025). Similar problems appear in Ubuntu-informed teaching and STEAM resource development, where teachers may support integration in principle but lack practical strategies, heritage knowledge, or sufficient time to transform local practices into formal learning experiences (Mkosi et al., 2023; O'Donoghue et al., 2024). These findings indicate that professional preparation must extend beyond creating favourable attitudes toward Indigenous Knowledge. Teachers require competence in identifying appropriate knowledge, evaluating disciplinary relationships, collaborating with community knowledge holders, maintaining cultural integrity, designing contextual resources, developing cognitively demanding tasks, and assessing the learning that results. Without these capabilities, even supportive policy may produce only symbolic inclusion because teachers lack the pedagogical means to operationalise Indigenous Knowledge substantively.

Professional development appears most promising when it is itself contextualised. Vaughn and de Beer (2020) show that conventional top-down approaches to science and

mathematics teacher development can fail to address the realities of rural teachers and culturally specific educational environments. Partnerships involving universities, schools, museums, and Indigenous knowledge holders can create stronger relationships between professional learning and local knowledge contexts. Similar needs are visible in mathematics education, where ongoing professional development is required to strengthen pedagogical content knowledge, respond to curriculum reform, and support Indigenous Knowledge integration (Jita & Badmus, 2025). These findings imply that teacher development should not reproduce the same epistemic distance that Indigenous Knowledge integration seeks to overcome. Generic workshops conducted outside community contexts may increase awareness without providing teachers with the practical knowledge needed to identify, validate, and teach local content responsibly. Professional learning is more likely to support substantive integration when it involves culturally grounded examples, community expertise, curriculum design practice, and opportunities to develop assessment tasks aligned with cognitively demanding contextual learning.

Curriculum and assessment alignment constitute a second major level of the implementation ecosystem. Formal policy recognition of Indigenous Knowledge does not necessarily translate into meaningful classroom practice when curriculum pacing, assessment requirements, teacher education, and institutional expectations remain organised around conventional disciplinary priorities. Fekumo and Phoshoko (2026) illustrate this policy-practice gap in secondary mathematics education, where teacher agency plays an important role but cannot fully overcome structural misalignment. Higher-education curriculum reform faces comparable institutional obstacles, particularly where Western theoretical traditions retain dominant status within formal programme structures (Buttner et al., 2026; Kangethe, 2025). These findings challenge interpretations that place responsibility for integration primarily on individual teachers. Teacher agency is important, but it operates within systems that determine what content is assessed, how time is allocated, which resources are legitimate, and what forms of knowledge receive institutional recognition. Sustainable integration therefore requires at least partial alignment among curriculum, assessment, teacher preparation, resource provision, institutional policy, and classroom practice.

Knowledge infrastructure represents a third level of the ecosystem because educational integration depends partly on whether Indigenous Knowledge can be documented, accessed, validated, and shared without compromising cultural integrity. Institutional repositories and digital libraries provide potential mechanisms for preserving and disseminating community knowledge, but fragmented documentation, limited technical infrastructure, and weak institutional coordination can restrict educational use (Buthelezi et al., 2024; Mdhluli et al., 2021). Digitisation also introduces substantial epistemic and ethical concerns. Knowledge may become technically accessible while simultaneously becoming detached from its language, social context, custodianship, and community obligations. Research on VhaVenda oral traditions illustrates how language, methodology, funding, politics, and cultural meaning can interact in the digitisation process (Kugara & Mokgoatšana, 2022). Consequently, increasing

the quantity of digital Indigenous Knowledge resources should not be treated as equivalent to improving educational quality. Resource development must also address cultural validation, intellectual ownership, linguistic integrity, access rights, and the participation of knowledge holders in decisions concerning representation.

Community participation is both a practical enabler and an epistemic requirement. Reciprocal relationships between universities, schools, and communities can provide authentic learning contexts and access to forms of expertise that may not be available within formal institutions (Mbah & Fonchingong, 2019). Gqibitole (2026) extends this argument by emphasising that curriculum decolonisation remains limited when Indigenous knowledge holders such as elders, healers, storytellers, and community leaders remain peripheral to decision making. Their participation should therefore not be reduced to supplying cultural information or validating examples selected by academics. Knowledge holders can contribute to identifying appropriate knowledge, interpreting meaning, deciding what should or should not be documented, developing contextual resources, evaluating cultural accuracy, and governing educational use. This deeper participation changes the nature of integration because authority over Indigenous Knowledge is not retained exclusively by formal institutions. Community participation therefore functions as a mechanism for both cultural authenticity and shared epistemic authority.

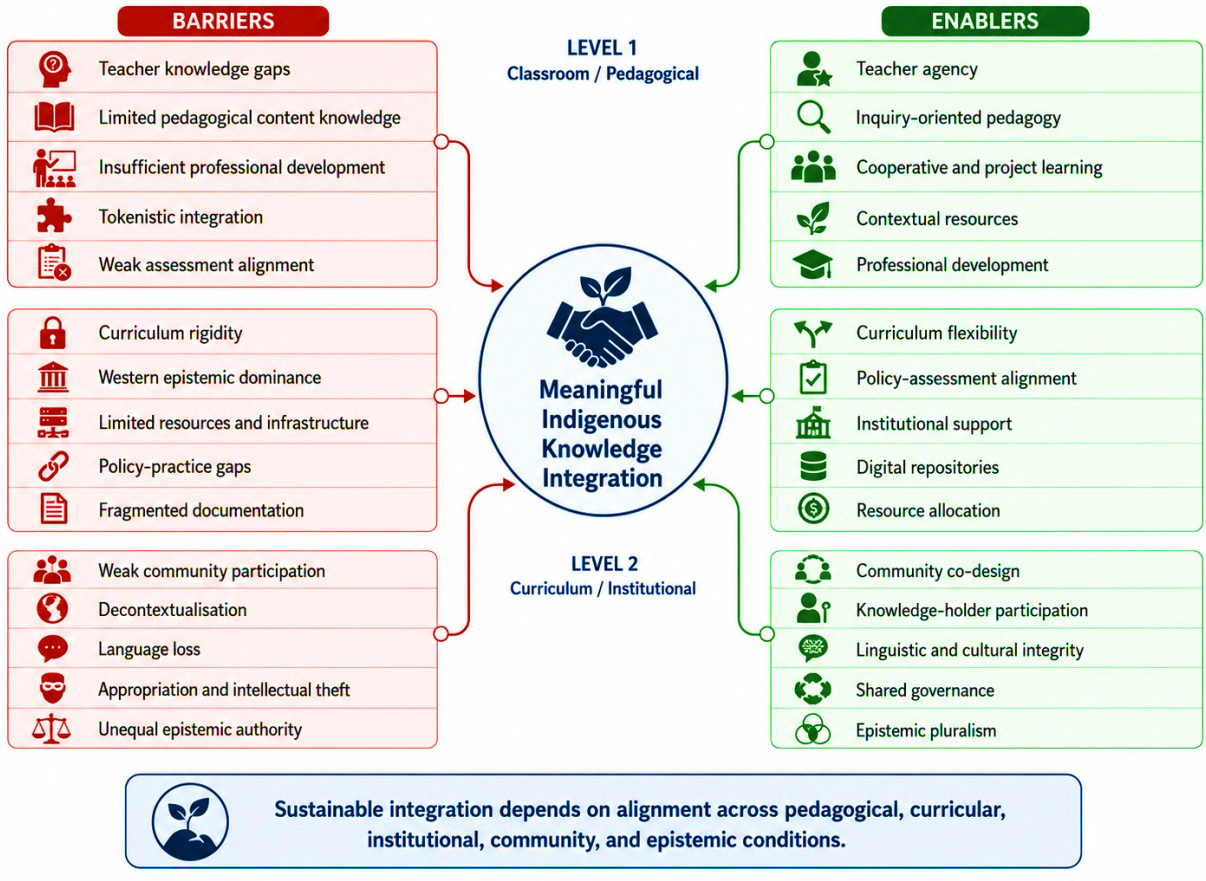


**Figure 4.** Barrier–Enabler Ecosystem for Sustainable Indigenous Knowledge Integration.

The ecosystem perspective provides a more adequate explanation of implementation than single-factor approaches because the identified conditions interact. Curriculum flexibility may have limited educational effect when teachers lack knowledge or pedagogical confidence. Strong teacher agency may remain constrained when high-stakes assessment rewards only conventional disciplinary reproduction. Digital infrastructure can improve access to resources while simultaneously increasing risks related to intellectual ownership and decontextualisation. Community co-design can strengthen authenticity but requires institutional mechanisms that recognise knowledge holders as legitimate curriculum partners. Institutional endorsement may increase visibility without altering classroom practice when professional development and resources are insufficient. These interactions indicate that meaningful integration should not be conceptualised as a discrete pedagogical technique that can simply be inserted into existing curriculum structures. It is more appropriately understood as an educational ecosystem in which pedagogical, curricular, technological, institutional, community, linguistic, and epistemic conditions collectively influence whether Indigenous Knowledge becomes substantively integrated, remains symbolic, or disappears from practice despite formal policy recognition.

The evidence also indicates that sustainable integration is fundamentally a matter of epistemic governance. Indigenous content can become highly visible within education while decision-making authority remains concentrated within formal academic institutions. Under such conditions, integration may reproduce the same hierarchy that decolonial curriculum initiatives seek to challenge. Participatory multiple-knowledge processes offer a different possibility because they require attention not only to what content is included but also to who determines its interpretation, legitimacy, and appropriate use (Masenya, 2022; Medvecky et al., 2023). The answer to RQ4 is therefore not reducible to providing more teacher training or more learning materials, although both are important. Meaningful transformation depends on sufficient alignment among teacher competence, curriculum flexibility, assessment, institutional recognition, resource infrastructure, community participation, and ethical knowledge governance. These conditions do not operate as statistically established moderators in this review, but the converging evidence suggests that they can enable or constrain the pathway through which Indigenous Knowledge becomes educationally meaningful.

## Integrative Synthesis: The Ethnoscience-to-Higher-Order Learning Framework

The four themes can now be integrated into a coherent account of how Indigenous Knowledge may become educationally relevant to higher-order learning. Table 1 identifies culturally situated knowledge and practices that can be recontextualised as educational content, while Table 2 demonstrates the representational and pedagogical forms through which such content becomes available within formal learning. Table 3 establishes that evidence concerning higher-order cognition varies substantially in directness and methodological strength, and Table 4 identifies the pedagogical, curricular, institutional, community, technological, and epistemic conditions that influence whether integration can

operate meaningfully. Considered separately, each theme addresses a different part of the review problem. Considered collectively, they support a mediated analytical architecture in which culturally situated knowledge does not move directly into higher-order cognitive outcomes. Instead, its educational significance depends on a sequence of interpretive, representational, pedagogical, and cognitive processes whose operation is shaped by broader enabling and constraining conditions.

The first component of the integrative framework is Indigenous Knowledge itself, understood as culturally situated epistemic resources rather than ready-made instructional content. Community practices, technologies, narratives, environmental observations, games, craft traditions, agricultural practices, and other forms of knowledge contain culturally meaningful systems of observation, explanation, experimentation, classification, and practical reasoning, but these intellectual structures may not be immediately visible within formal curriculum categories. Ethnoscientific interpretation therefore provides an initial educational mechanism by which relevant relationships can be identified without assuming that Indigenous Knowledge must be translated entirely into the categories of formal science. The synthesis suggests that this interpretation is most defensible when it preserves cultural context and avoids reducing Indigenous practices to decorative illustrations. Meaningful ethnoscientific interpretation therefore performs two tasks simultaneously: it makes relevant intellectual structures educationally accessible while retaining sufficient attention to the social, cultural, linguistic, and epistemic relationships through which the knowledge acquires meaning.

Contextual learning-resource development constitutes the next component because interpreted knowledge must be represented in forms through which learners can encounter, investigate, discuss, or apply it. The evidence demonstrates that these forms can include narratives, folklore, Indigenous games, community expertise, artefacts, local environmental phenomena, technologies, visual resources, projects, digital repositories, and culturally grounded scenarios. However, the synthesis consistently shows that resources do not possess predetermined cognitive effects. Their educational significance depends on the pedagogy organised around them. A culturally meaningful narrative can remain a memorisation task, while the same narrative can support inferential reasoning when learners are required to interpret and evaluate it. A digital repository can function as passive information storage, or it can support inquiry and comparison when embedded in purposeful instructional activity. Contextual learning resources should therefore be understood as representational infrastructure that creates opportunities for learning rather than as independent causes of educational outcomes.

Knowledge-integration pedagogy provides the mechanism through which relationships between Indigenous and disciplinary knowledge are organised. The findings indicate substantial variation in the depth of this relationship. At a relatively superficial level, Indigenous Knowledge may be juxtaposed with formal content or used as an example after disciplinary concepts have already been established. At deeper levels, learners compare

explanations, examine evidence, investigate local phenomena, participate in collaborative discussion, develop projects, or engage directly with community knowledge holders. This variation is theoretically important because it determines whether Indigenous Knowledge remains culturally visible but epistemically subordinate or becomes an active participant in knowledge construction. Dialogue, inquiry, cooperative learning, project-based activity, problem posing, evidence evaluation, and community co-design appear across the reviewed literature as mechanisms capable of supporting more substantive integration. The framework therefore places pedagogy between contextual resources and cognitive outcomes because pedagogical design determines how knowledge relationships are enacted in actual learning activity.

Cognitively demanding engagement provides the most immediate connection between knowledge integration and higher-order learning. The evidence does not support the proposition that cultural contextualisation alone is a cognitive mechanism. Higher-order outcomes become more plausible when pedagogical activities require learners to analyse, infer, evaluate, reflect, investigate, create, solve problems, make decisions, or transfer knowledge. This interpretation explains the asymmetry identified in Table 3. Studies measuring achievement, engagement, or retention demonstrate educational benefits but provide limited information about the cognitive processes involved, whereas studies explicitly examining metacognition, critical thinking, inferential reasoning, reflection, creative application, or epistemic agency provide stronger support for higher-order learning. The same Indigenous Knowledge resource can therefore generate different outcomes under different pedagogical conditions. Higher-order learning should be understood as a conditional result of what learners are asked to do intellectually with culturally situated knowledge rather than as an intrinsic property of the knowledge itself.

The enabling and constraining conditions identified in Theme 4 surround the entire framework rather than appearing only at its endpoint. Teacher knowledge and pedagogical content knowledge influence whether culturally situated practices can be interpreted responsibly and connected with disciplinary content. Curriculum flexibility and assessment alignment determine whether teachers have sufficient space to organise contextual inquiry rather than simply cover prescribed content. Resource availability and digital infrastructure affect the forms through which Indigenous Knowledge becomes accessible, while community participation influences cultural authenticity, validation, and epistemic authority. Institutional recognition affects whether contextualised practices can be sustained beyond isolated teacher initiatives, and knowledge governance determines whether educational use respects ownership, language, community rights, and appropriate representation. These conditions should not be interpreted as statistically established moderating variables, but the recurring evidence indicates that they can strengthen or weaken the operation of the proposed pathway at multiple stages.

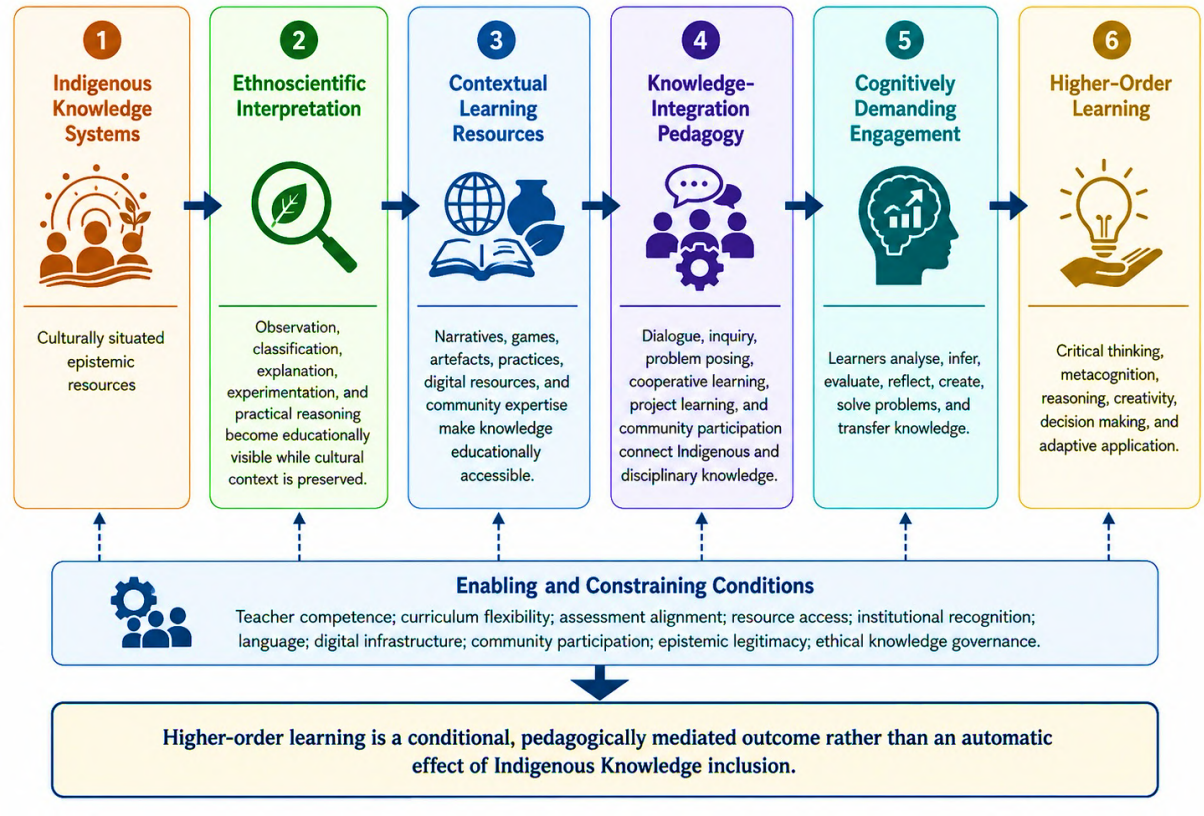


**Figure 5.** Ethnoscience-to-Higher-Order Learning Framework.

The resulting framework makes three related contributions to the interpretation of the literature. First, it distinguishes curricular presence from epistemic participation. Indigenous Knowledge can appear visibly within textbooks, examples, or classroom activities without contributing substantively to interpretation, inquiry, dialogue, or knowledge construction. Second, the framework distinguishes direct cognitive evidence from indirect and conceptual evidence, thereby preventing achievement, retention, engagement, or contextual relevance from being automatically treated as higher-order learning. Third, it positions the cognitive contribution of Indigenous Knowledge within a mediated pedagogical process rather than attributing higher-order outcomes directly to cultural content. These distinctions enable a more cautious but also more theoretically meaningful interpretation of the evidence. Indigenous Knowledge is neither academically peripheral nor automatically cognitively beneficial. Its educational potential depends on how it is interpreted, represented, integrated, pedagogically activated, and supported by the surrounding educational ecosystem.

This mediated interpretation also avoids two opposing positions that can distort Indigenous Knowledge research. A deficit position treats Indigenous Knowledge as supplementary cultural material that must be validated primarily through established disciplinary categories before it can become educationally legitimate. A romanticised position assumes that Indigenous Knowledge produces educational or cognitive benefits simply because it is culturally authentic. The evidence supports neither assumption. Indigenous Knowledge can provide epistemically rich and contextually meaningful material for formal education, but its consequences depend on the quality of interpretation, resource design,

pedagogy, learner cognitive engagement, and institutional and community conditions. Epistemic pluralism provides a useful qualification because productive integration does not require Indigenous and disciplinary knowledge to become indistinguishable. Differences in purpose, evidence, explanation, and validation can themselves provide opportunities for critical comparison and reasoning when pedagogically mediated (Seehawer & Breidlid, 2021; Westermeyer-Jaramillo et al., 2026).

The framework should therefore be understood as an analytical architecture rather than a universal instructional protocol. The reviewed studies represent highly specific linguistic, cultural, disciplinary, national, and institutional contexts. Sepedi folklore, Karanga beer-brewing practices, Ghanaian Adinkra symbolism, South African Life Sciences, Zimbabwean environmental knowledge, Indigenous technologies, and other knowledge forms derive educational significance partly from the relationships that connect them with particular communities and places. Direct transplantation of these practices into unrelated educational settings would contradict the contextual principles on which the framework is based. The framework instead identifies relationships that can guide context-sensitive interpretation: culturally situated knowledge requires responsible ethnoscientific interpretation; educational use requires appropriate contextual resources; integration requires pedagogy that establishes substantive knowledge relationships; higher-order learning requires cognitively demanding learner activity; and all of these processes depend on enabling pedagogical, institutional, community, and epistemic conditions.

The central proposition emerging from the synthesis is therefore conditional but substantial. African Indigenous Knowledge can contribute to higher-order learning when cultural relevance is accompanied by meaningful epistemic participation and pedagogical activity that demands analysis, evaluation, inquiry, reflection, creativity, problem solving, or transfer. The contribution of Indigenous Knowledge is not located merely in making formal education culturally familiar, although contextual relevance remains important. Its stronger educational potential lies in providing alternative observations, explanations, practices, representations, and knowledge relationships that can become objects of serious intellectual engagement. When learners are required to examine these resources critically and constructively, epistemic diversity can become a basis for reasoning rather than an obstacle to disciplinary learning. The Ethnoscience-to-Higher-Order Learning Framework therefore captures not a guaranteed causal pathway but a set of educational conditions under which culturally situated knowledge can become a meaningful resource for higher-order learning.

## CONCLUSION

This systematic thematic synthesis demonstrates that African Indigenous Knowledge can function as a substantive epistemic and pedagogical resource within formal education rather than merely as supplementary cultural content. Across the reviewed evidence, Indigenous Knowledge was recontextualised through ethnomathematics, Indigenous Chemistry, environmental practices, community knowledge, heritage resources, local technologies, oral traditions, and culturally grounded scientific experiences. These forms of

knowledge entered education through different levels of integration, ranging from simple inclusion to contextual integration, knowledge co-production, and epistemic pluralism. The findings therefore show that the educational significance of Indigenous Knowledge depends not simply on whether it is present in the curriculum, but on the epistemic role it is allowed to perform within teaching and learning.

The review also demonstrates that contextual learning resources are important but insufficient by themselves. Narratives, folklore, Indigenous games, cultural symbols, artefacts, digital repositories, technologies, community expertise, and locally grounded practices become educationally meaningful only when they are activated through appropriate pedagogy. Dialogue, inquiry, cooperative learning, project-based learning, problem posing, comparison of explanations, and community participation were repeatedly identified as mechanisms that enable learners to engage more actively with Indigenous and disciplinary knowledge. This distinction is important because culturally relevant materials can still be used in passive or reproductive ways. Their stronger educational potential emerges when learners are required to interpret, investigate, compare, construct, evaluate, and apply knowledge within meaningful contexts.

The evidence concerning higher-order learning is promising but uneven. Direct evidence was found for metacognition, critical thinking, inferential and evaluative reasoning, reflection, creative interpretation, and epistemic agency, while a larger body of research reported indirect outcomes such as achievement, conceptual understanding, engagement, retention, and contextual application. These findings do not justify the claim that Indigenous Knowledge automatically produces higher-order learning. Instead, they support a mediated interpretation in which higher-order outcomes become more plausible when culturally situated knowledge is ethnoscientifically interpreted, represented through contextual resources, integrated with disciplinary knowledge, and enacted through cognitively demanding pedagogical activity. Distinguishing direct, indirect, and conceptual evidence is therefore essential for avoiding overstatement of cognitive effects.

The principal theoretical contribution of the review is the Ethnoscience-to-Higher-Order Learning Framework. The framework conceptualises higher-order learning as a conditional outcome of Indigenous Knowledge Systems, ethnoscientific interpretation, contextual learning resources, knowledge-integration pedagogy, and cognitively demanding engagement, while recognising the influence of teacher competence, curriculum flexibility, assessment alignment, institutional support, community participation, resource access, language, digital infrastructure, epistemic legitimacy, and ethical knowledge governance. The framework should not be interpreted as a universal causal model, but as a context-sensitive analytical architecture. Its central proposition is that Indigenous Knowledge becomes most educationally consequential when cultural relevance is combined with meaningful epistemic participation and intellectually demanding pedagogy.

## LIMITATIONS

This review is limited by its reliance on Scopus as the sole bibliographic database and by the defined publication period of 2010–2026. Relevant studies indexed elsewhere, particularly local African publications, books, book chapters, theses, conference proceedings, and community-based documentation, may therefore have been excluded. In addition, the original executable Scopus search history and the detailed field-by-field filtering log were not preserved, although the principal search architecture and selection counts were retained. These factors reduce the exact reproducibility of the initial database-filtering process and may have affected the comprehensiveness of the evidence base.

A second limitation concerns the heterogeneity and distribution of the included evidence. The 37-study synthesis incorporated qualitative, quantitative, mixed-method, quasi-experimental, participatory, conceptual, and review studies, which prevented meta-analysis and limited direct comparison across outcomes. Formal retrospective MMAT scoring was not undertaken because complete archived appraisal records were unavailable. The evidence was also geographically uneven, with Southern African contexts particularly prominent. Moreover, direct evidence of higher-order learning was narrower than the literature reporting achievement, engagement, retention, or conceptual understanding. The proposed framework should therefore be interpreted as an integrative synthesis rather than a statistically validated causal model.

## RECOMMENDATIONS

Future research should explicitly operationalise higher-order learning constructs such as critical thinking, metacognition, reasoning, creativity, problem solving, inquiry, decision making, knowledge transfer, and adaptive application rather than inferring them from general achievement or engagement measures. Stronger comparative, longitudinal, and mixed-method designs are needed to determine whether cognitively demanding outcomes are sustained across time and transferable across contexts. Greater geographical representation beyond the currently dominant Southern African settings is also necessary. Teacher professional development should focus on ethnoscientific interpretation, contextual resource design, inquiry-oriented pedagogy, assessment alignment, and collaboration with Indigenous knowledge holders. Curriculum and institutional policies should create space for meaningful epistemic participation, while digitalisation and resource development should protect cultural integrity, language, ownership, consent, and community authority. The Ethnoscience-to-Higher-Order Learning Framework should therefore be tested and refined across diverse African educational contexts rather than applied as a universal instructional prescription.

**Author Contributions**

The authors have sufficiently contributed to the study, and have read and agreed to the published version of the manuscript.

**Funding**
This research received no external funding.

**Acknowledgment**
During the preparation of this work, the authors used ChatGPT to enhance the clarity of the writing. After using ChatGPT, the authors reviewed and edited the content as needed and took full responsibility for the publication's content. The authors gratefully acknowledge their respective institutions, Delta State University, Nigeria, and Moulay Ismail University, Morocco, for providing an academic environment that supported the preparation and completion of this systematic review. The authors also appreciate the scholarly community whose published research provided the evidence base for the synthesis presented in this study.

**Conflict of Interests**
The authors declare no conflict of interest.

## REFERENCES

Adetunji, R. O., & Ade-Ibijola, A. (2026). AI-driven adaptation of local African games for training small businesses. *Discover Education, 5*(1), 769. https://doi.org/10.1007/s44217-026-01605-8

Adeyeye, B. A., & Mason, J. (2020). Opening futures for Nigerian education–Integrating educational technologies with Indigenous knowledge and practices. *Open Praxis, 12*(1), 27–37. https://doi.org/10.5944/openpraxis.12.1.1055

Age, T. J. (2025). Performance-based assessment: A transformative approach to enhancing mathematics learning in Ubuntu classrooms across Sub-Saharan Africa. *European Journal of STEM Education, 10*(1), 04. https://doi.org/10.20897/ejsteme/16420

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269–287. https://doi.org/10.1002/(SICI)1098-2736(199903)36:3<269::AID-TEA3>3.0.CO;2-T

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Armah, M., Tetteh, A., Okebukola, P., Gallard-Martinez, A., & Ikpah, C. (2026). Improving African students' understanding of cybersecurity using African Indigenous pedagogy and technology. *Discover Education, 5*(1), 587. https://doi.org/10.1007/s44217-026-01465-2

Boakye-Yiadom, F., Donkor, E. K., & Mensah, R. O. (2025). Exploring the role of project-based learning in higher education to promote Indigenous knowledge through sculpture students' engagement with Ghanaian Adinkra symbols. *Discover Global Society, 3*(1), 4. https://doi.org/10.1007/s44282-024-00135-8

Buthelezi, S. C., Ocholla, D., & Dlamini, P. (2024). Strategies for documenting and disseminating Indigenous knowledge at a South African university. *South African Journal of Information Management, 26*(1), a1648. https://doi.org/10.4102/sajim.v26i1.1648

Buttner, D. P., Mphambukeli, T. N., & Nel, V. J. (2026). Leveraging Indigenous Knowledge to decolonise planning theory curricula and practice for empowering future planners. *Journal of Sustainable Architecture and Civil Engineering, 39*(1), 7–19. https://doi.org/10.5755/j01.sace.39.1.41270

Chahine, I. C. (2020). Towards African humanicity: Re-mythogolising Ubuntu through reflections on the ethnomathematics of African cultures. *Critical Studies in Teaching and Learning, 8*(2), 95–111. https://doi.org/10.14426/cristal.v8i2.251

Dyantyi, N. (2026). Rethinking teacher education for sustainable development: Stories from a South African university. *International Journal of Learning, Teaching and Educational Research, 25*(2), 1003–1019. https://doi.org/10.26803/ijlter.25.2.44

Fekumo, B., & Phoshoko, M. M. (2026). The Triple Helix of curriculum reform in secondary mathematics education: Teacher agency and the integration of Indigenous Knowledge Systems in post-apartheid South Africa. *International Journal of Learning, Teaching and Educational Research, 25*(5), 969–992. https://doi.org/10.26803/ijlter.25.5.43

Gqibitole, K. (2026). Healing the curriculum: Decoloniality, Africanization and indigenization through Indigenous knowledge holders. *OIDA International Journal of Sustainable Development, 19*(6), 189–196. https://doi.org/10.64211/oidaijsd190614

Gumbo, M. T., Nnadi, F. O., & Anamezie, R. C. (2021). Amalgamating Western science and African Indigenous Knowledge Systems in the measurement of gravitational acceleration. *Journal of Baltic Science Education, 20*(5), 729–739. https://doi.org/10.33225/JBSE/21.20.729

Jita, L. C., & Badmus, O. T. (2025). Understanding the landscape of mathematics teachers' professional development in South Africa: A review of literature. *Prometeica, 32*, e16367. https://doi.org/10.34024/prometeica.2025.32.16367

Jiyane, L. (2026). Exploring storytelling methodologies on childhood development: A collaborative study with early childhood education practitioners in rural settings. *Perspectives in Education, 44*(1), 20–37. https://doi.org/10.38140/PIE.V44I1.8692

Kangethe, S. M. (2025). The prospects and challenges of indigenising Higher Education Institutions (HEIs)' curriculum in South Africa. *African Journal of Social Work, 15*(6), 51–60. https://doi.org/10.4314/ajsw.v15i6.5

Kugara, S. L., & Mokgoatšana, S. (2022). Challenges presented by digitisation of VhaVenda oral tradition: An African Indigenous Knowledge Systems perspective. *HTS Teologiese Studies/Theological Studies, 78*(3), a7428. https://doi.org/10.4102/hts.v78i3.7428

Latip, A., Hernani, & Kadarohman, A. (2024). Local and Indigenous knowledge (LIK) in science learning: A systematic literature review. *Journal of Turkish Science Education, 21*(4), 651–667. https://doi.org/10.36681/tused.2024.035

Lentz, G., Waghid, Z., & Livingston, C. (2026). Cultivating epistemic agency through translanguaging: An Africanising framework for English teacher education in South Africa. *International Journal of Learning, Teaching and Educational Research, 25*(4), 1109–1142. https://doi.org/10.26803/ijlter.25.4.49

Lewis, A., & Smith, D. (1993). Defining higher order thinking. *Theory Into Practice, 32*(3), 131–137. https://doi.org/10.1080/00405849309543588

Mademabe, M. P., Omodan, B. I., & Tsotetsi, C. T. (2022). Incorporation of Indigenous Knowledge in the mathematical geometry discipline at a TVET college. *REDIMAT, 11*(3), 296–312. https://doi.org/10.17583/redimat.7890

Malapane, O. L., Musakwa, W., Chanza, N., & Radinger-Peer, V. (2022). Bibliometric analysis and systematic review of Indigenous Knowledge from a comparative African perspective: 1990–2020. *Land, 11*(8), 1167. https://doi.org/10.3390/land11081167

Maledu, A. D., & Ngobeni, N. E. (2026). Folklore-based pedagogy for literacy and critical thinking in Sepedi classrooms. *Reading & Writing, 17*(1), a669. https://doi.org/10.4102/rw.v17i1.669

Masalimova, A. R., Zheltukhina, M. R., Sergeeva, O. V., Kosarenko, N. N., Tsomartova, D. A., & Smirnova, L. M. (2024). Science teaching in BRICS: A systematic review of pedagogical approaches and challenges. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(4), em2432. https://doi.org/10.29333/ejmste/14434

Masenya, T. M. (2022). Decolonization of Indigenous Knowledge Systems in South Africa: Impact of policy and protocols. *International Journal of Knowledge Management, 18*(1). https://doi.org/10.4018/IJKM.310005

Mbah, M., & Fonchingong, C. (2019). Curating Indigenous knowledge and practices for sustainable development: Possibilities for a socio-ecologically-minded university. *Sustainability, 11*(15), 4244. https://doi.org/10.3390/su11154244

Mdhluli, T. D., Mokgoatšana, S., Kugara, S. L., & Vuma, L. (2021). Knowledge management: Preserving, managing and sharing Indigenous knowledge through digital library. *HTS Teologiese Studies/Theological Studies, 77*(2), a6795. https://doi.org/10.4102/hts.v77i2.6795

Medvecky, F., Metcalfe, J., & Riedlinger, M. (2023). Response to: "Looking back to launch forward: A self-reflexive approach to decolonising science education and communication in Africa": Recognizing and validating multiple knowledge ecologies. *Journal of Science Communication, 22*(4), Y03. https://doi.org/10.22323/2.22040403

Mkhwebane, L. N. (2024). Life sciences teachers' integration of Indigenous knowledge: A vision for making science classrooms culturally responsive. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(8), em2483. https://doi.org/10.29333/ejmste/14859

Mkhwebane, L. N., Mavuru, L., Makhubalo, P. T., & Sethole, K. N. (2025). Life Sciences teachers' views on using interactive whiteboards to integrate Indigenous Knowledge in cellular respiration teaching. *International Journal of Learning, Teaching and Educational Research, 24*(8), 562–584. https://doi.org/10.26803/ijlter.24.8.24

Mkosi, N. N., Mavuso, M. P., & Olawumi, K. B. (2023). Using Ubuntu values in integrating African Indigenous Knowledge into teaching and learning: A review of literature. *International Journal of Learning, Teaching and Educational Research, 22*(5), 140–159. https://doi.org/10.26803/ijlter.22.5.7

Ngcoza, K. M. (2019). Education for sustainable development at the problem-posing nexus of re-appropriated heritage practices and the science curriculum. *Southern African Journal of Environmental Education, 35*. https://doi.org/10.4314/sajee.v35i1.9

Nwigwe, E. O. (2026). Understanding place-based education in Nigeria: A structured narrative review of its status, barriers, and African comparative insights. *Social Sciences & Humanities Open, 13*, 102409. https://doi.org/10.1016/j.ssaho.2025.102409

Nxumalo, S. A., & Mncube, D. W. (2018). Using Indigenous games and knowledge to decolonise the school curriculum: Ubuntu perspectives. *Perspectives in Education, 36*(2), 103–118. https://doi.org/10.18820/2519593X/pie.v36i2.9

Nyamupangedengu, E., & Khupe, C. (2024). Turning the art of Karanga beer brewing into a science: An example of humanising Biology teaching and learning. *Educational Research for Social Change, 13*(1), 107–121. https://doi.org/10.17159/2221-4070/2023/v13i1a7

O'Donoghue, R., van Staden, W., Bhurekeni, J., Snow-Macleod, J., & Ndlamlenze, L. (2024). A formative study towards the inclusion of Indigenous technologies and knowledge practices in science, technology, engineering, arts, and mathematics (STEAM) curriculum settings. *Educational Research for Social Change, 13*(1), 34–47. https://doi.org/10.17159/2221-4070/2023/v13i1a3

Odora Hoppers, C. A. (Ed.). (2002). *Indigenous knowledge and the integration of knowledge systems: Towards a philosophy of articulation*. New Africa Books.

Okeke, U. K., & Ramaila, S. (2025). Decolonizing secondary school science education through contextualized instruction: An exploration of the nature of science, adaptive expertise, instructional implications and pedagogical frameworks for knowledge integration. *Social Sciences & Humanities Open, 11*, 101614. https://doi.org/10.1016/j.ssaho.2025.101614

Oladejo, A. I., Olateju, T. T., Okebukola, P. A., Sanni, R., Akintoye, H., Onowugbeda, F., Ayanwale, M. A., Agbanimu, D. O., Saibu, S., & Adam, U. (2025). Breaking barriers to meaningful learning in STEM subjects in Africa: A systematic review of the Culturo-Techno-Contextual Approach. *Sustainability, 17*(5), 2310. https://doi.org/10.3390/su17052310

Seehawer, M. (2018). South African science teachers' strategies for integrating Indigenous and Western knowledges in their classes: Practical lessons in decolonisation. *Educational Research for Social Change, 7*(Special Edition), 91–110. https://doi.org/10.17159/2221-4070/2018/v7i0a7

Seehawer, M., & Breidlid, A. (2021). Dialogue between epistemologies as quality education: Integrating knowledges in Sub-Saharan African classrooms to foster sustainability learning and contextually relevant education. *Social Sciences & Humanities Open, 4*(1), 100200. https://doi.org/10.1016/j.ssaho.2021.100200

Sefoka, T. S., & Chuene, K. J. (2025). Life sciences learners' views on the integration of Indigenous Knowledge into Indigenous Knowledge-related topics using a cooperative learning approach: A case of South African Grade 10 classroom. *Eurasia Journal of Mathematics, Science and Technology Education, 21*(5), em2633. https://doi.org/10.29333/ejmste/16311

Seneque, M., Kalungu-Banda, A., Kalungu-Banda, M., & Munyaka, S. (2023). Ubuntu: A philosophy for systems transformation. *Journal of Awareness-Based Systems Change, 3*(1), 129–147. https://doi.org/10.47061/jasc.v3i1.6201

Seroto, J., & Higgs, P. (2024). African Indigenous education in the postcolonial period: A critical reflection. *Journal of Education, 95*, 148–168. https://doi.org/10.17159/2520-9868/i95a08

Singh-Pillay, A., & Madlala, A. (2026). Legitimising Indigenous knowledge systems as a pathway to sustainable development. *Discover Education, 5*(1), 87. https://doi.org/10.1007/s44217-025-01062-9

Snively, G., & Corsiglia, J. (2001). Discovering Indigenous science: Implications for science education. *Science Education, 85*(1), 6–34. https://doi.org/10.1002/1098-237X(200101)85:1<6::AID-SCE3>3.0.CO;2-R

Sotero, M. C., Alves, Â. G. C., Arandas, J. K. G., & Medeiros, M. F. T. (2020). Local and scientific knowledge in the school context: Characterization and content of published works. *Journal of Ethnobiology and Ethnomedicine, 16*(1), 23. https://doi.org/10.1186/s13002-020-00373-5

Tanyanyiwa, V. I. (2019). Indigenous Knowledge Systems and the teaching of climate change in Zimbabwean secondary schools. *SAGE Open, 9*(4). https://doi.org/10.1177/2158244019885149

Tawanda, T., & Mudau, A. V. (2024). The influence of Indigenous Knowledge on Chemistry metacognition. *F1000Research, 12*, 589. https://doi.org/10.12688/f1000research.131685.4

Ugwuoke, U., Tetteh, A., Okebukola, P., & Ogonenwe, J. (2025). Enhancing ICT retention through Indigenous pedagogy. *Discover Education, 4*(1), 512. https://doi.org/10.1007/s44217-025-00962-0

van Wyk, M. M. (2014). Conceptualizing an Afrocentric-Indigenous pedagogy for an inclusive classroom environment. *Mediterranean Journal of Social Sciences, 5*(4), 292–299. https://doi.org/10.5901/mjss.2014.v5n4p292

Vaughn, M. S., & de Beer, J. (2020). Contextualising science and mathematics teacher professional development in rural areas. *Perspectives in Education, 38*(2), 213–226. https://doi.org/10.18820/2519593X/pie.v38.i2.14

Westermeyer-Jaramillo, M., Quintriqueo-Millán, S. E., & Villarroel Cárdenas, V. M. (2026). Scientism and intercultural epistemological pluralism in the teaching of natural science. *Revista Brasileira de Educação, 31*, e310006. https://doi.org/10.1590/S1413-24782026310006