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A Systematic Review on Pedagogical Challenges of Secondary Science Teachers in Indigenous Peoples Education Schools

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ABSTRACT

This systematic review examined the pedagogical challenges encountered by secondary science teachers in Indigenous Peoples Education (IPEd) schools, the factors contributing to those challenges, and the strategies and interventions reported to address them. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, with literature sourced exclusively from Google Scholar using systematically constructed search terms spanning pedagogical challenges, science education, and indigenous education contexts. From an initial pool of 453 records, eleven peer-reviewed empirical studies published between 2018 and 2026 were selected following rigorous screening and eligibility assessment. The included studies were drawn from the Philippines, South Africa, Ghana, and Indonesia, and employed predominantly qualitative designs. Findings reveal four pervasive pedagogical challenges: the integration of indigenous knowledge systems with formal Western science content, language of instruction barriers, resource inadequacy, and the management of culturally complex classroom dynamics. These challenges are shaped by an interlocking system of structural, institutional, and dispositional factors, including centralized curriculum frameworks that leave no formal space for indigenous epistemologies, inadequate pre-service and in-service professional development, and teacher beliefs that position indigenous knowledge as supplementary rather than foundational to science education. Three broad categories of strategy were identified: community-embedded pedagogical approaches, collaborative professional learning, and teacher-driven curriculum adaptation and material improvisation. A critical cross-cutting finding is the complete absence, across all eleven studies, of a formally institutionalized professional development program specifically designed to support secondary science teachers in IPEd contexts — indicating a significant gap between inclusive education policy and classroom-level implementation. This review provides evidence-based insights to inform curriculum development, educational policy, and teacher preparation programs aimed at strengthening science teaching in indigenous education settings globally.

INTRODUCTION

Science education serves as a cornerstone of human development, equipping learners with the critical thinking, inquiry skills, and scientific literacy necessary to navigate an increasingly complex world. However, for Indigenous Peoples Education (IPEd) schools-institutions designed to serve culturally distinct communities in geographically isolated and marginalized settings-science education presents a uniquely challenging terrain. Secondary science teachers in these contexts must simultaneously navigate the demands of a centralized national curriculum, the epistemological tensions between Western scientific frameworks and indigenous knowledge systems (IKS), and the practical realities of resource-constrained, culturally diverse classrooms (Laviste & Valdez, 2025; Mlotshwa & Tsakeni, 2024). Despite growing global recognition of the importance of culturally responsive and inclusive science education, empirical evidence on the specific pedagogical challenges faced by science teachers in IPEd school settings remains fragmented, geographically limited, and methodologically scattered.

The problem is significant. Indigenous learners continue to experience persistent educational disadvantage globally, partly due to the failure of mainstream science curricula to engage meaningfully with indigenous ways of knowing (Nesterova, 2024). Teachers working in IPEd schools occupy a particularly difficult position: they are expected to deliver scientifically rigorous content while simultaneously honoring, integrating, and sustaining the cultural knowledge systems that give meaning to their students' lived experiences (Mkhwebane, 2024; Opoku & James, 2020). Without sustained institutional support, targeted professional development, and curriculum frameworks that explicitly accommodate IKS, these teachers are left to navigate these tensions largely on their own.

This systematic review addresses that gap by synthesizing empirical evidence on the pedagogical challenges encountered by secondary science teachers in IPEd schools. Specifically, it aims to identify the common challenges reported in existing literature, examine the factors contributing to those challenges, and analyze the pedagogical strategies and interventions that have been proposed or implemented to address them. By mapping

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the current state of evidence, this review seeks to inform future research directions, educational policy, curriculum development, and professional development programs aimed at strengthening science teaching in indigenous education contexts.

MATERIALS AND METHODS

This study utilized the systematic literature review (SLR) method to synthesize existing literature on the pedagogical challenges encountered by secondary science teachers in Indigenous Peoples Education (IPEd) schools, including the factors influencing these challenges, strategies and interventions reported to address them, and existing research gaps to inform future policy and professional development. The review procedure followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page, 2021). Article selection was carried out according to the four major phases outlined in the PRISMA flowchart: identification, screening, assessment of eligibility, and final inclusion. In the identification stage, relevant literature was identified from the search engine Google Scholar using the search terms "pedagogical challenges," "teaching challenges," "instructional challenges," "teaching difficulties," "instructional barriers," "pedagogical issues," "classroom challenges," "teaching obstacles," "instructional practices," "teaching experiences," "science teachers," "secondary science teachers," "high school science teachers," "science educators," "biology," "chemistry," "physics," "earth science," "STEM," "Indigenous Peoples Education," "IPEd," "indigenous education," "indigenous schools," "indigenous communities," "indigenous learners," "indigenous students," "indigenous people," "tribal schools," "culturally responsive education," "culturally relevant education," "culturally sustaining pedagogy," "indigenous knowledge," and "indigenous knowledge systems." In the screening stage, the identified relevant literature was screened by selecting peer-reviewed journal articles published in 2015–2026. In the eligibility stage, the selected journal articles were further screened by excluding studies conducted in mainstream schools without an explicit Indigenous Peoples Education or Indigenous community context, studies focusing exclusively on non-science subjects such as mathematics, language, or social studies, studies involving only elementary teachers, preschool teachers, higher education faculty, students, administrators, or parents without secondary science teacher participants, studies that did not investigate pedagogical challenges or related instructional issues, non-empirical publications such as literature reviews, theoretical papers, editorials, conference abstracts, dissertations, blogs, and news articles, duplicate records, and articles not written in English or without accessible full-text versions. In the inclusion stage, articles were included in the study if they were published between 2015 and 2026, involved secondary science teachers teaching in IPEd schools or Indigenous education settings as participants, examined pedagogical challenges, instructional practices, or classroom-related barriers in Indigenous science education contexts, covered science subject areas including Biology, Chemistry, Physics, Earth Science, Environmental Science, or integrated science, were written in English, employed qualitative, quantitative, or mixed-methods designs, were peer-reviewed journal articles, and were available in full-text format. Studies that met the inclusion criteria were analyzed using content analysis.

LITERATURE REVIEW

Science Education in Indigenous Contexts: Global Perspectives

The relationship between formal science education and indigenous communities has long been characterized by tension. Western science, as institutionalized in school curricula worldwide, operates from a positivist epistemological tradition that privileges empirical, observable, and universally replicable knowledge — a framework that frequently marginalizes or renders invisible the place-based, relational, and holistic knowledge systems of indigenous peoples (Gillette & Singleton, 2022). This epistemological incompatibility is not merely philosophical; it has concrete pedagogical consequences. Teachers who operate at the intersection of these knowledge systems face what scholars describe as epistemological border-crossing — the complex, often uncomfortable process of moving between scientific and indigenous ways of knowing in classroom practice (Handayani *et al.*, 2019). Studies conducted in South Africa, Indonesia, Ghana, and the Philippines consistently find that science teachers experience significant discomfort, uncertainty, and inadequate preparation when tasked with integrating IKS into formal science instruction (Mlotshwa & Tsakeni, 2024; Seehawer, 2018).

A systematic review of pedagogical practices for integrating indigenous knowledge systems in science teaching by Ikpe *et al.* (2024) identified that while diverse strategies exist — ranging from ethnoscience approaches to place-based learning and community-engaged pedagogy — the field remains dominated by localized, small-scale qualitative studies with limited transferability across contexts. This fragmentation reflects a broader structural issue: indigenous science education research tends to emerge in response to localized policy mandates rather than from a consolidated, evidence-based global framework. The result is a body of literature that is rich in contextual detail but weak in cross-contextual synthesis — precisely the gap this systematic review seeks to address.

Pedagogical Challenges of Science Teachers in IPEd Schools

Empirical studies consistently identify several interrelated categories of pedagogical challenge for science teachers in indigenous education settings. The most pervasive of these is the challenge of integrating indigenous knowledge with Western science content. Mkhwebane (2024), in a

qualitative study with five life sciences teachers in South Africa, found that inadequate teacher training, limited institutional support, and negative attitudes toward IKS created a cycle of disengagement from meaningful integration. Teachers often defaulted to surface-level acknowledgment of IKS — a token inclusion that neither honored indigenous ways of knowing nor effectively enhanced science learning. Similarly, Mlotshwa and Tsakeni (2024) found that natural sciences teachers in KwaZulu-Natal experienced epistemological boundary tensions and feared disrespecting cultural practices, leading to avoidance of substantive IKS integration in practical work.

Language of instruction constitutes another critical pedagogical barrier. Opoku and James (2020), in an ethnographic study of Biology teachers and Akan indigenous knowledge holders in Ghana, identified the foreign language of instruction as a fundamental challenge, arguing that the use of English or other colonial languages in science classrooms actively suppresses indigenous scientific vocabulary and disconnects learners from the cultural meaning embedded in local knowledge systems. This finding resonates with the experiences of science teachers in the Philippines, where Laviste and Valdez (2025) documented how science teachers working with Indigenous Peoples students in remote Mindanao settings struggled to make scientific content meaningful across deep cultural and linguistic divides.

Resource inadequacy is a third consistently reported challenge. Across multiple national contexts, science teachers in indigenous schools report operating without adequate teaching and learning materials, laboratory equipment, and curriculum support structures tailored to indigenous learners (Esparrago-Kalidas, 2023; Babaran, 2025). Babaran's (2025) quantitative study across six public secondary schools in the Philippines found that while IPEd program implementation was rated satisfactory overall, teacher training and instructional materials were the dimensions receiving the weakest scores — suggesting that the most pedagogically consequential supports remain underdeveloped.

Factors Influencing Pedagogical Challenges in IPEd Science Teaching

The challenges described above do not arise in isolation. Research consistently identifies systemic, institutional, and personal factors that shape science teachers' capacity to teach effectively in IPEd contexts. At the systemic level, centralized curriculum frameworks represent a major constraint. Handayani *et al.* (2019), in a study of Indonesian secondary science teachers building indigenous learning communities through lesson study, found that centrally mandated science content left teachers with minimal flexibility to incorporate local knowledge, effectively institutionalizing the marginalization of IKS within the formal curriculum. Opoku and James (2020) similarly identified centralized curriculum as a barrier to teaching Akan culturally-specific environmental ethics in Ghanaian secondary schools.

At the institutional level, the absence of targeted professional development programs for IPEd science teachers is a recurring theme. Mkhwebane (2024) argued that teachers' deficiencies in pedagogical content knowledge related to IKS integration are not individual failures but systemic outcomes of teacher education programs that have not adequately prepared educators for indigenous classroom realities. This finding is echoed by Magnaye (2026), who found that high school science teachers in IPEd schools in Bataan, Philippines, navigated institutional challenges with remarkable resilience but did so largely without structured professional support, relying instead on personal ingenuity and community relationships to sustain culturally responsive practice.

Personal and professional beliefs about the legitimacy and educational value of indigenous knowledge also emerge as a significant influencing factor. Photo and McKnight (2024) found that South African science teachers demonstrated low levels of IK awareness, and that this limited awareness was directly linked to reduced willingness and capacity to integrate IKS meaningfully. Where teachers held deficit views of indigenous knowledge — perceiving it as unscientific or incompatible with formal curriculum goals — integration efforts were correspondingly superficial or entirely absent. Addressing these beliefs, the literature suggests, requires not only professional development in IKS content but sustained engagement with indigenous communities and decolonizing pedagogical frameworks (Seehawer, 2018; Esparrago-Kalidas, 2023).

Strategies and Interventions in IPEd Science Teaching

Despite the challenges documented above, the literature also surfaces a range of strategies through which science teachers have navigated the demands of IPEd contexts with varying degrees of success. Culturally sustaining pedagogy (CSP) has emerged as a theoretically grounded framework for guiding practice. Esparrago-Kalidas (2023), in a narrative inquiry study with teachers serving Lumad learners in Bukidnon, Philippines, found that CSP-oriented teachers who integrated place-based learning, community knowledge holders, and indigenous storytelling into science lessons achieved stronger student engagement and cultural affirmation — though implementation was consistently constrained by institutional resistance and resource limitations.

Collaborative approaches involving indigenous community elders and knowledge keepers have also shown promise. Handayani *et al.* (2019) demonstrated that lesson study groups that included indigenous elders as co-participants produced richer, more contextually embedded science lessons than those designed exclusively by formally trained teachers. This finding points to the potential of community-embedded professional learning models as a more equitable and effective alternative to conventional top-down professional development.

Similarly, Seehawer (2018) found that participatory action research involving collaborative workshop cycles enabled South African science teachers to develop genuine integration strategies — including story-based content delivery, community excursions, and bilingual concept mapping — that honored both scientific rigor and indigenous epistemologies.

Taken together, the literature underscores that effective science teaching in IPEd contexts is not merely a technical challenge of content delivery but a deeply political and ethical endeavor that requires teachers to exercise cultural competence, pedagogical creativity, and advocacy within often unsupportive institutional structures. The synthesis of existing evidence through this systematic review thus provides a critical foundation for understanding the nature and scope of these challenges and for identifying the most promising pathways toward more equitable, culturally responsive science education for indigenous learners worldwide.

RESULTS AND DISCUSSION

This section presents the findings of the systematic review, synthesizing empirical evidence drawn from eleven peer-reviewed studies published between 2018 to 2026, drawn from the Philippines, South Africa, Ghana, and Indonesia. The studies collectively address the pedagogical challenges secondary science teachers encounter in Indigenous Peoples Education (IPEd) schools, the factors contributing to those challenges, and the strategies and interventions reported to address them. The findings are presented and discussed in relation to the three research questions guiding this review.

Table 1: Review of literature on the Teachers' Pedagogical Challenges in Science Education

#	Author/s (Year)	Country / Location / Setting	Field of Study (Level)	Method	Key Findings
1	Laviste & Valdez (2025)	Philippines; Kalamansig, Sultan Kudarat; IPED schools in remote areas	Science education — IP learners (Secondary)	Qualitative Phenomenological; Moustakas Thematic Analysis; interviews	Science teachers face significant challenges teaching in remote IPED settings including culturally responsive teaching demands, resource gaps, limited community engagement, and absence of ongoing professional development; teachers navigate tension between Western science and indigenous knowledge systems.
2	Magnaye (2026)	Philippines; Bataan; various IPED schools	Science education — IPED context (Secondary)	Qualitative Phenomenological; semi-structured interviews + document analysis; 10 high school science teachers	Twelve key themes identified including integrating indigenous knowledge into science content, adapting materials to cultural contexts, and using constructivist approaches; culturally sustaining practices foster student engagement and affirm cultural identity but institutional challenges persist.
3	Mlotshwa & Tsakeni (2024)	South Africa; Harry Gwala District, KwaZulu-Natal; natural sciences classrooms	Natural sciences — IKS integration (Secondary)	Qualitative Exploratory case study; interpretive paradigm; interviews with 3 teachers and 2 subject advisors	Teachers face challenges integrating culture-specific IKS into practical work including epistemological border-crossing tensions, negative learner perceptions of IKS, and fear of disrespecting cultures; limited curriculum guidance and inadequate teacher preparation are key systemic barriers.
4	Mkhwebane (2024)	South Africa; Gauteng Province; secondary schools	Life sciences — IK integration (Grades 10–12)	Qualitative In-depth interviews + lesson observations; 5 life sciences teachers	Challenges include inadequate teacher training, limited institutional support structures, negative attitudes toward indigenous knowledge, and deficiencies in pedagogical content knowledge for IK integration; intensified teacher training and ICT-assisted IK digitization are recommended.

5	Opoku & James (2020)	Ghana; senior high schools; Akan indigenous community context	Biology — culturally-specific environmental ethics (Secondary)	Qualitative Interpretivist; ethnographic naturalistic; in-depth conversational interviews with IK-holders and biology teachers	Predicted challenges include stigma attached to culturally-specific ethics, requirement of scientific proof and experimentation, use of foreign language of instruction, centralized curriculum structure, democracy and political biases; awareness of these challenges can guide curriculum development.
6	Seehawer (2018)	South Africa; secondary schools; indigenous and Western knowledge integration	Science education — decolonizing pedagogy (Secondary)	Qualitative Participatory action research; collaborative workshops + reflection notes + semi-structured interviews; 5 science teachers	Science teachers developed integration strategies through collaborative reflection; challenges include epistemological border-crossing tensions, relevance of indigenous knowledge to learners, and decolonizing the Western-centric science curriculum; participatory approaches support teacher agency.
7	Handayani *et al.* (2019)	Indonesia; secondary schools; indigenous community context	Science education — indigenous learning community (Secondary)	Qualitative post-colonial theory; indigenous research paradigm; interviews + focus groups + cultural talks with teachers and elders	Secondary science teachers face challenges building indigenous learning communities through lesson study including marginalization of local wisdom, epistemological tensions between Western science and indigenous knowledge, and limited institutional recognition of IK in science curricula.
8	Esparrago-Kalidas (2023)	Philippines; Pangantucan, Bukidnon; Lumad indigenous formal education	Science and general education — CSP implementation (Secondary)	Qualitative Narrative inquiry; semi-structured in-person interviews; 5 purposively selected teachers	Challenges implementing Culturally Sustaining Pedagogy among Lumad learners include institutional constraints, limited resource availability, identity tensions between mainstream and indigenous educational values, and inadequate preparation for place-based and community-rooted teaching approaches.
9	Babaran (2025)	Philippines; Alfonso Lista; 6 public secondary schools	IPEd program implementation (Secondary)	Quantitative Descriptive-correlational; adapted questionnaire; 156 secondary school teachers	IPEd implementation is rated satisfactory across pedagogy, IKSPs, curriculum, language, teacher training, materials, and assessment; teaching experience and participation in IPEd training significantly enhance implementation effectiveness; more IPEd-specific professional development is recommended.
10	Mlotshwa & Tsakeni (2024b)	South Africa; selected schools; natural sciences practical work	Natural sciences — IKS practical integration (Secondary)	Qualitative Case study; interpretive approach; interviews and classroom observations	IKS integration in practical work reveals socio-cultural complexities including enacted traditional gender roles among learners and cultural avoidance of certain activities; structural curriculum constraints and centralized control limit meaningful, contextually responsive IKS integration.

11	Photo & McKnight (2024)	South Africa; science classrooms; various secondary schools	Science education — IK awareness and curriculum (Secondary)	Mixed methods Interviews + document analysis; qualitative and descriptive components	Science teachers demonstrate low levels of indigenous knowledge awareness, limiting meaningful IK integration; inadequate curriculum guidelines and lack of structured IK professional development are primary barriers; a teacher-centered IK guideline is recommended to support classroom integration.

Pedagogical Challenges of Secondary Science Teachers in IPEd Schools

The most consistently and prominently reported pedagogical challenge across the included studies is the integration of indigenous knowledge systems with formal Western science content. This challenge manifests not merely as a curriculum design problem but as a lived epistemological tension that shapes how science teachers plan lessons, select examples, facilitate discussions, and assess learning. Mlotshwa and Tsakeni (2024a) found that natural sciences teachers in South Africa experienced acute discomfort when IKS practices introduced cultural norms — such as gendered taboos around certain natural materials — that were difficult to accommodate within the procedural demands of practical science work. Rather than disrupting classroom flow, many teachers chose avoidance, quietly sidelining IKS content to preserve lesson efficiency. Mkhwebane (2024) similarly documented how life sciences teachers in Gauteng defaulted to token or superficial acknowledgment of IKS, driven by deficiencies in pedagogical content knowledge and an absence of curriculum-embedded guidance on how integration should look in practice.

Language of instruction emerged as a second major and often underappreciated pedagogical challenge. Opoku and James (2020) provided particularly detailed documentation of how the use of English as the medium of science instruction in Ghanaian senior high schools actively suppressed indigenous scientific vocabulary, severed students' conceptual connections to lived cultural experience, and effectively positioned indigenous environmental knowledge as non-scientific. This finding resonates strongly with the Philippine context documented by Laviste and Valdez (2025), where science teachers working with IP students in Sultan Kudarat identified language barriers as a daily instructional reality — one that required continuous, energy-intensive improvisation with no formal curricular support. The persistence of this challenge across geographically and culturally distinct contexts — Ghana, the Philippines, South Africa, and Indonesia — points to a structural rather than incidental problem, one rooted in the colonial inheritances embedded within national science curricula.

Resource inadequacy constitutes a third pervasive challenge. Babaran (2025), in the only quantitative study in this review, found that among all dimensions of IPEd program implementation assessed across 156 secondary teachers in the Philippines, teacher training and instructional materials received the weakest scores. This pattern was mirrored in the qualitative evidence: Esparrago-Kalidas (2023) found that teachers implementing culturally sustaining pedagogy among Lumad learners in Bukidnon were compelled to improvise culturally relevant instructional materials independently, without institutional provision. Magnaye (2026) documented similar conditions in Bataan IPEd schools, where teachers leveraged environmental resources, community artifacts, and oral traditions as substitute teaching materials — creative responses to resource scarcity that, while admirable, placed undue burden on individual teachers and produced inconsistent educational experiences across classrooms.

Classroom management in culturally complex settings adds a fourth dimension to the pedagogical challenge landscape. Handayani *et al.* (2019) found that Indonesian secondary science teachers building indigenous learning communities through lesson study encountered significant difficulties facilitating classroom interactions that honored both scientific inquiry norms and the relational protocols of indigenous learning cultures, which emphasize communal consensus and elder guidance over individual experimentation. The tension between inquiry-based science pedagogy and indigenous communal epistemologies is a recurrent but insufficiently theorized theme in the literature — one that points to the need for pedagogical frameworks specifically designed for indigenous science classroom contexts rather than adapted from mainstream science education theory.

Factors Contributing to Pedagogical Challenges in IPEd Science Teaching

The synthesis reveals that the pedagogical challenges described above are not produced by individual teacher failings but by an interlocking system of structural, institutional, and dispositional factors. At the structural level, centralized curriculum frameworks consistently emerge as the dominant enabling condition for pedagogical difficulty. Opoku and James (2020) identified centralized curriculum as a key barrier to teaching Akan culturally-specific environmental ethics, noting that the prescribed content and assessment structures left no formal space for indigenous knowledge to be treated as legitimate science. Handayani *et al.* (2019) corroborated this finding in the Indonesian context, where nationally mandated science content effectively crowded out the flexibility needed for indigenous knowledge integration.

This structural factor is particularly consequential because it operates upstream of all other challenges: even the most culturally competent, well-resourced, and committed science teacher cannot integrate IKS meaningfully within a curriculum framework that has not been designed to accommodate it.

Inadequate pre-service and in-service professional development is the second most consistently identified contributing factor. Mkhwebane (2024) argued compellingly that teachers' struggles with IKS integration reflect the failure of teacher education programs rather than individual inadequacy, noting that most South African life sciences teachers had received no formal preparation in how to incorporate indigenous knowledge into science curricula. Babaran (2025) quantitatively confirmed this pattern in the Philippine context, finding a significant positive relationship between the number of IPEd-specific training sessions attended and the quality of IPEd program implementation — suggesting that targeted professional development does produce measurable improvements but remains insufficiently provided. Mlotshwa and Tsakeni (2024b) further found that teachers who had developed their IKS integration capacity did so largely through self-directed community engagement rather than formal institutional support, a finding that highlights both teacher resilience and systemic neglect.

Teacher beliefs and personal attitudes toward indigenous knowledge constitute a third important contributing factor, operating at the dispositional level. Photo and McKnight (2024) found that South African science teachers' low indigenous knowledge awareness directly shaped their willingness and capacity to integrate IKS, with teachers who held deficit views of indigenous knowledge — perceiving it as unscientific, superstitious, or incompatible with formal curriculum goals — engaging in consistently more superficial integration practices. Seehawer (2018) similarly found that teachers' initial skepticism about the educational legitimacy of indigenous knowledge was a primary obstacle to meaningful integration, one that required sustained collaborative reflection to overcome. These findings suggest that attitudinal transformation — not just skills acquisition — is a necessary component of effective professional development for IPEd science teachers.

Socio-cultural complexity within indigenous classrooms adds a further layer of contributing factors that is unique to the IPEd context. Mlotshwa and Tsakeni (2024b) documented how IKS integration in practical science work surfaced cultural gender roles and taboos that disrupted established science pedagogy, creating tensions that teachers were neither trained nor institutionally supported to navigate. Esparrago-Kalidas (2023) found that teachers in Lumad schools experienced identity tensions — caught between the expectations of the formal education system and the values and relational protocols of the indigenous communities they served — which added psychological dimensions to what are often treated as purely pedagogical challenges.

Strategies and Interventions Addressing Pedagogical Challenges in IPEd Science Teaching

Despite the severity and pervasiveness of the challenges identified, the reviewed studies also surface a range of strategies that science teachers have employed — with varying degrees of institutional support — to sustain culturally responsive and pedagogically effective science teaching in IPEd contexts. Three broad categories of strategy emerge from the synthesis: community-embedded pedagogical approaches, collaborative professional learning, and curriculum adaptation and material improvisation.

Community-embedded pedagogical approaches represent the most culturally grounded and consistently effective strategy documented in the literature. Magnaye (2026) found that IPEd science teachers in Bataan who systematically incorporated environmental resources, cultural artifacts, and community narratives into science lessons achieved stronger student engagement and deeper connections between scientific concepts and lived experience. Handayani *et al.* (2019) demonstrated that science lesson study groups that included indigenous elders as co-participants produced richer, more contextually relevant lessons than those developed exclusively by formally trained teachers — a finding that challenges the conventional boundary between formal educational expertise and community knowledge. These community-embedded approaches are particularly significant because they position indigenous knowledge holders as legitimate pedagogical partners rather than peripheral informants, thereby rebalancing the epistemological hierarchy that centralized science curricula tend to reproduce.

Collaborative professional learning, particularly through participatory and reflective models, emerged as the second most consistently effective strategy. Seehawer (2018) documented how a participatory action research process involving weekly collaborative workshops enabled five South African science teachers to move from initial skepticism about IKS integration to developing genuinely innovative integration strategies — including bilingual concept mapping, community excursions, and story-based science content delivery — over an extended period of structured reflection. This finding carries important implications for professional development design: the transformative outcomes observed by Seehawer (2018) were produced not by one-time workshops or top-down training sessions but by sustained, teacher-led collaborative inquiry grounded in classroom reality and community relationship. Mlotshwa and Tsakeni (2024a) similarly found that teachers who engaged in collegial reflection about IKS integration challenges developed more nuanced and contextually sensitive integration practices than those working in professional isolation.

Curriculum adaptation and material improvisation represent a third category of strategy, one that is simultaneously a testament to teacher creativity and an

indictment of institutional neglect. Esparrago-Kalidas (2023) documented how CSP-oriented teachers in Lumad schools self-developed culturally relevant science materials, drawing on community objects, local ecological knowledge, and indigenous storytelling formats to scaffold scientific concept acquisition. Laviste and Valdez (2025) found that science teachers in remote Philippine IP schools employed improvised demonstrations, locally sourced materials, and culturally familiar analogies to bridge the gap between abstract scientific content and students' lived cultural experience. While these improvised strategies often produced meaningful learning experiences, their sustainability is precarious — dependent entirely on individual teacher effort and creativity rather than on systemic curricular provision.

A cross-cutting finding of considerable significance is that none of the eleven included studies reported the existence of a formally institutionalized, evidence-based, and regularly evaluated professional development program specifically designed to support secondary science teachers in IPEd schools. This absence is itself a major finding: it reveals that, despite the existence of IPEd policy frameworks in countries such as the Philippines and South Africa, the translation of inclusive education policy into sustained, targeted teacher support for science instruction in indigenous settings remains critically incomplete. Future research should prioritize the design, implementation, and rigorous evaluation of such programs, drawing on the community-embedded and collaborative professional learning models that the current evidence base identifies as most promising.

CONCLUSION

This systematic review synthesized eleven empirical studies to examine the pedagogical challenges of secondary science teachers in Indigenous Peoples Education schools, the factors contributing to those challenges, and the strategies employed to address them. The findings present a coherent and concerning picture: science teachers in IPEd contexts are expected to accomplish extraordinarily complex pedagogical work — bridging Western science and indigenous knowledge systems, adapting centralized curricula for culturally specific learner populations, and sustaining student engagement across deep linguistic and epistemological divides — while receiving minimal institutional preparation, support, or recognition for this work.

The most pervasive pedagogical challenges identified are the integration of indigenous knowledge with formal science content, language of instruction barriers, resource inadequacy, and the management of culturally complex classroom dynamics. These challenges are produced and sustained by an interlocking system of structural factors — centralized curriculum frameworks that leave no formal space for indigenous epistemologies, inadequate pre-service and in-service professional development, and institutional cultures that continue to treat indigenous knowledge as supplementary rather than foundational to science education. Teacher beliefs and personal attitudes toward IKS represent an additional dispositional layer of contributing factors, one that professional development programs must address alongside skill-building if meaningful and sustained change is to occur.

The strategies documented in the literature — community-embedded pedagogical approaches, collaborative professional learning, and teacher-driven curriculum adaptation — offer promising models for practice and policy, but their impact is currently constrained by their informal, unsupported, and unsystematized nature. No included study reported a formally institutionalized program that consistently and equitably equipped secondary science teachers to meet the demands of IPEd science teaching. This finding is the most urgent implication of this review: indigenous education policy, in the Philippines and beyond, has advanced considerably at the legislative and curricular framework level, but has not yet produced the teacher preparation and professional support infrastructure necessary to realize its ambitions in actual science classrooms.

This review carries several limitations. The geographic concentration of included studies in the Philippines, South Africa, Ghana, and Indonesia limits the generalizability of findings to other indigenous education contexts. The predominance of qualitative designs, while appropriate for exploring teachers' lived experiences, restricts the ability to draw conclusions about the prevalence or magnitude of specific challenges across larger teacher populations. Furthermore, the absence of longitudinal studies means that the long-term outcomes of the strategies documented in the literature remain largely unknown.

Future research should prioritize longitudinal studies that track the development of science teachers' pedagogical capacity in IPEd contexts over time, comparative studies that examine how different national policy and institutional conditions shape pedagogical challenge and response, and rigorous evaluations of community-embedded and collaborative professional learning models that the current evidence base identifies as most promising. Above all, research and policy must converge on the recognition that equitable science education for indigenous learners is not achievable without placing the preparation, ongoing development, and institutional support of IPEd science teachers at the center of national education reform agendas.

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