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Weaving Ways Of Knowing: A Narrative Inquiry Into How Zambian Biology Teachers And Community Elders Navigate The Integration Of Indigenous And Scientific Knowledge

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Abstract- This study explores the integration of indigenous knowledge into formal biology education in Zambia, addressing the critical gap between policy commitments and actual school practices. While Zambian communities possess rich ecological wisdom developed over generations, formal biology education has historically marginalized this heritage. This has alienated learners from their cultural identities and perpetuating colonial hierarchies that position Western science as exclusively legitimate. This narrative inquiry explored how biology teachers, community elders and secondary school learners experience and navigate the integration of indigenous and scientific knowledge systems. Employing a mixed methods framework anchored in narrative inquiry, the research prioritized qualitative depth while incorporating quantitative breadth. Data were gathered through in-depth interviews with 12 biology teachers and 8 community elders, focus discussions with 126 learners across seven schools and a survey of 55 biology teachers from six Zambian provinces. Narrative, thematic and descriptive statistical analyses were applied accordingly. Findings revealed that over 80% of teachers valued indigenous knowledge integration, yet only 20% practiced it regularly, constrained by lack of curriculum guidance (82%), examination pressure (78%) and insufficient resources (70%). Community elders confirmed the erosion of traditional knowledge transmission while expressing strong conditional openness to school partnerships. Learners were able to make sense of both knowledge systems thoughtfully. They felt strong and valued when their culture was welcomed, but feel left out and disengaged when looked down upon. The study concludes that meaningful integration requires systemic intervention addressing curriculum reform, assessment, professional development and authentic community partnerships, contributing practical recommendations for culturally-responsive biology education that affirms learner identity while maintaining scientific rigour.

Keywords/phrases: Indigenous Knowledge Integration, Culturally-responsive pedagogy, Narrative inquiry, Epistemology, Biology education, Community elders, Decolonizing education.

I. Chapter One – Introduction

1. Introduction

Education systems worldwide are increasingly recognizing the value of integrating indigenous knowledge with formal curricula, particularly in science education. This recognition stems from growing awareness that knowledge production is not the exclusive domain of Western scientific traditions, but rather a diverse, culturally-embedded process that varies across communities and contexts. In Zambia, as in many African nations, indigenous communities have developed sophisticated understandings of their natural environments over countless generations. This knowledge, transmitted through oral traditions, cultural practices, and direct engagement with ecosystems, represents a rich repository of ecological wisdom that remains largely untapped in formal educational settings.

The integration of indigenous knowledge into biology education presents both significant opportunities and considerable challenges. On one hand, such integration promises to make science education more culturally relevant, enhance learner engagement, and validate the knowledge systems that learners encounter in their home communities. On the other hand, teachers face complex epistemological questions about how to respectfully and meaningfully bring together knowledge systems that emerge from different worldviews, methodologies, and ways of knowing. These challenges are not merely technical or pedagogical; they touch upon fundamental questions of identity, power, cultural preservation, and the very nature of knowledge itself.

This research emerges from a critical observation; while Zambian communities possess profound place-based ecological wisdom developed through centuries of observation, experimentation, and relationship with the land, formal biology education often sidelines this heritage as irrelevant or inferior to Western scientific knowledge. This marginalization creates a painful disconnection for learners who must navigate between the knowledge valued in their homes and communities and the knowledge legitimized in schools. The consequences extend beyond academic performance to issues of cultural identity, self-worth, and the perpetuation of colonial-era hierarchies that position indigenous knowledge as primitive and Western science as universally superior.

Despite policy commitments to culturally-responsive education in Zambia and elsewhere in Africa, the practical realities of integrating indigenous and scientific knowledge remain underexplored. We know little about the lived experiences of teachers who attempt this integration, the strategies they employ, the tensions they navigate, and the outcomes they observe. Similarly, the perspectives of community elders, the custodians and transmitters of indigenous knowledge, regarding the incorporation or exclusion of their wisdom from formal education remain largely unexamined. Perhaps most importantly, we lack understanding of how learners themselves make sense of educational experiences that engage both knowledge systems.

This chapter establishes the foundation for a narrative inquiry into how Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge. It begins by providing background and context for understanding the research problem, then articulates the specific problem this study addresses. The chapter proceeds to state the research purpose and objectives, pose the research questions that guide the inquiry, and discuss the significance and rationale for this work. Finally, it outlines the scope and limitations of the study, defines key terms, and provides an organizational overview of the dissertation.

1.1. Background and Rationale

1.1.1. Indigenous Knowledge in Zambian Communities

Zambia's diverse ethnic groups, including the Bemba, Tonga, Lozi, Chewa, Luvale, and many others, have developed sophisticated knowledge systems about their local ecosystems over millennia. This knowledge encompasses understanding of plant

taxonomy and medicinal properties, animal behaviour and ecology, soil types and agricultural practices, weather patterns and seasonal cycles, and the complex interconnections among living organisms and their environments. Indigenous knowledge in Zambian communities is not simply a collection of facts about nature; it is deeply embedded in worldviews that emphasize relationality, reciprocity, and responsibility toward the natural world. For example, traditional healers possess detailed knowledge of hundreds of medicinal plants, including their identification, preparation, dosage, and applications for various ailments. This knowledge often includes understanding of plant chemistry, ecological relationships, and sustainable harvesting practices that ensure continued availability of resources. Similarly, traditional farmers have developed intricate systems of crop rotation, intercropping, and pest management adapted to local soil conditions, climate patterns, and available resources. These practices reflect generations of observation, experimentation, and adaptation, processes that parallel the scientific method, albeit within different epistemological frameworks.

Indigenous knowledge in Zambia is characteristically holistic, integrating what Western science separates into distinct disciplines such as biology, chemistry, agriculture, medicine, and meteorology. It is also fundamentally place-based, developed through intimate, sustained engagement with specific landscapes and ecosystems. This knowledge is typically transmitted orally through stories, proverbs, songs, rituals, and apprenticeship relationships, creating strong intergenerational bonds and connecting knowledge to cultural identity and community belonging. However, this rich knowledge heritage faces multiple threats. Urbanization, migration, and the global spread of Western cultural norms are disrupting traditional transmission pathways. Younger generations increasingly pursue formal education and urban employment, reducing opportunities for learning from elders and engaging directly with traditional practices. Meanwhile, formal education systems, legacies of colonial administration, have historically devalued indigenous knowledge; presenting Western science as the only legitimate way of knowing about the natural world. This devaluation has led many community members, particularly educated youth, to dismiss traditional knowledge as outdated superstition, creating a crisis of cultural continuity and knowledge loss.

1.1.2. Formal Biology Education in Zambia

The Zambian formal education system, established during British colonial rule and maintained largely intact after independence in 1964, follows a structure and curriculum heavily influenced by British educational models. Biology is introduced in lower grades and continues through to university, with content covering topics such as cell biology, genetics, evolution, ecology, plant and animal physiology, and human biology. The curriculum is standardized nationally, with learning objectives, content, and assessment largely determined by the Curriculum Development Centre and the Examinations Council of Zambia.

Biology education in Zambian schools faces numerous challenges that affect its quality and relevance. These include large class sizes that limit opportunities for inquiry-based learning and practical work, insufficient laboratory equipment and materials for hands-on experimentation. Additionally, there has always been limited access to current

textbooks and learning resources, teacher shortages and inadequate professional development opportunities, examination-oriented teaching that emphasizes memorization over understanding, and significant disparities in resources and quality between urban and rural schools. Perhaps most fundamentally, the biology curriculum remains largely decontextualized from Zambian realities. Textbooks predominantly feature examples from temperate ecosystems rather than tropical African environments. Plant and animal species used to illustrate concepts are often exotic to Zambia, while local species go unmentioned. Agricultural and health applications emphasize industrial farming and modern medicine while ignoring traditional practices. This disconnect means that learners must master knowledge about organisms and ecosystems they may never encounter, while the rich biological diversity and indigenous ecological knowledge of their own communities remain invisible in their education. This situation reflects broader patterns in science education across post-colonial Africa, where curricula designed for European contexts were transplanted with minimal adaptation. The implicit message is that authentic science happens elsewhere, conducted by foreigners, concerning phenomena distant from learners lived experiences. This alienation undermines engagement, perpetuates dependencies on external expertise, and fails to prepare learners to address local environmental and health challenges using contextually appropriate knowledge and methods.

1.1.3. Policy Context for Integration

Recent decades have seen growing recognition, both internationally and within Zambia, of the need for more culturally-responsive and contextually-relevant science education. The Zambian Education Curriculum Framework (2013) explicitly calls for "learning that is rooted in the values, traditions and aspirations of the Zambian people" and recognizes that "indigenous knowledge should be integrated with other knowledge systems." The framework emphasizes that education should help learners "appreciate and respect their cultural heritage while developing capabilities for the 21st Century. Similarly, the Zambia Education Act (2011) mandates that education should "promote the cultural, social and economic development of Zambia" and inculcate in learners an appreciation of their cultural heritage. At the continental level, the African Union's Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) recognizes indigenous knowledge as a crucial resource for sustainable development and calls for its integration with modern science and technology.

Despite these policy commitments, implementation remains limited and inconsistent. The actual biology curriculum documents and textbooks show minimal integration of indigenous knowledge. Teacher training programs rarely address how to identify, validate, and incorporate indigenous knowledge into science teaching. Assessment practices continue to focus exclusively on Western scientific knowledge, providing no incentive for teachers to invest time and energy in integration efforts. The gap between policy rhetoric and classroom reality reflects deeper challenges; uncertainty about what integration should look like in practice, concerns about scientific rigor and examination preparation, lack of resources and professional development support, and unresolved epistemological questions about the relationship between indigenous and scientific knowledge.

1.1.4. The Promise and Challenges of Integration

Integrating indigenous knowledge with formal biology education offers multiple potential benefits. For learners, such integration can make science education more culturally relevant and meaningful by connecting academic learning to familiar contexts, practices, and concerns. This relevance may enhance engagement and motivation, as learners see their own experiences and communities' knowledge reflected and valued in the curriculum. Integration can affirm learners' cultural identities and challenge the implicit message that their communities' ways of knowing are inferior, potentially improving self-esteem and academic confidence.

From a pedagogical perspective, indigenous knowledge provides rich contexts for inquiry-based learning. Investigating questions such as "How do traditional healers identify medicinal plants?" or "Why do farmers plant certain crops together?" can develop scientific skills of observation, classification, hypothesis formation, and evidence evaluation. Consequently, learners get engaged with knowledge systems that use different but equally rigorous methods of investigation. Comparing indigenous and scientific explanations for phenomena can develop critical thinking and epistemological awareness.

Integration also has potential benefits for communities and for knowledge preservation. When schools engage respectfully with indigenous knowledge, they validate community wisdom and create new contexts for intergenerational knowledge transmission. Elder-teacher-learner collaborations can strengthen school-community relationships and position elders as valued knowledge holders rather than as obsolete relics of the past. For indigenous knowledge systems themselves, engagement with formal education creates documentation opportunities and may attract renewed interest from younger generations.

However, integration also presents significant challenges and risks. Epistemological differences between indigenous and scientific knowledge raise difficult questions about how to present multiple explanations for the same phenomena without creating confusion or relativism. Indigenous knowledge emerges from holistic worldviews that emphasize relationships, spirituality, and reciprocity with nature, while Western science operates within materialist frameworks that seek universal, objective explanations through reductionist methods. Teachers must navigate how to honour both without either trivializing indigenous knowledge or undermining scientific understanding.

Power dynamics and questions of authenticity present additional challenges. When teachers or curriculum developers extract specific practices or facts from indigenous knowledge systems and insert them into Western educational frameworks, they risk decontextualizing and distorting that knowledge. Who has authority to determine which indigenous knowledge is valid for school inclusion? How can schools avoid appropriating indigenous knowledge while still making it accessible to learners? These questions become particularly acute when sacred or proprietary knowledge is involved. Practical challenges include teachers' often limited knowledge of indigenous traditions, especially if they teach in communities different from their own cultural backgrounds. Time constraints in an already crowded curriculum make it difficult to add new content.

Examination pressures incentivize focusing on material likely to appear on standardized tests, which rarely include indigenous knowledge. Inadequate resources, written materials, lesson plans, professional development, makes integration dependent on individual teacher initiative and creativity.

1.1.5. The Need for Narrative Inquiry

Given these complexities, understanding how integration actually happens, or fails to happen, in Zambian classrooms requires moving beyond policy analysis or theoretical discussion to examine the lived experiences of those involved. Some teachers, despite receiving no explicit training or support, find ways to bridge indigenous and scientific knowledge in their teaching. Their stories of how they navigate epistemological tensions, engage with community knowledge holders, design learning experiences, and manage practical constraints offer invaluable insights that cannot be captured through surveys or standardized observations alone.

Similarly, community elders possess unique perspectives on whether and how their knowledge is being incorporated into formal education, what they observe happening to traditional knowledge transmission in the context of schooling, and what they hope for regarding the relationship between their knowledge and formal education. Their narratives provide essential context for understanding integration efforts from the community side.

Learners' experiences of navigating between knowledge systems, how they make sense of apparent contradictions, what they find engaging or confusing, how integration affects their sense of identity and belonging, are crucial for understanding the actual effects of integration efforts. Their stories reveal whether integration achieves its intended goals of relevance, engagement, and cultural affirmation.

Narrative inquiry, with its emphasis on understanding experience through the stories people tell, provides an appropriate methodological framework for this investigation. It recognizes that human experience is fundamentally narrative in character; we understand our lives, make meaning of events, and communicate with others through stories. By gathering and analyzing the narratives of teachers, elders, and learners, this research can develop rich, contextual understanding of integration as a lived phenomenon rather than an abstract policy goal.

1.2. Statement of the Research Problem

Despite policy commitments to integrating indigenous knowledge with formal biology education in Zambia, and notwithstanding the potential benefits of such integration for learner engagement, cultural affirmation, and contextual relevance, we lack deep understanding of how this integration is actually experienced and navigated by those most directly involved. Specifically, three critical knowledge gaps exist.

First, while we know that some teachers attempt to bridge indigenous and scientific knowledge in their biology teaching, we do not understand their lived experiences of doing so. What pedagogical strategies do they employ? What tensions and challenges do they encounter? How do they navigate epistemological differences between knowledge systems? What supports or constraints do they experience from curriculum

requirements, community expectations, and institutional contexts? How do their own cultural backgrounds and knowledge influence their approaches? What outcomes do they observe, and how do they make sense of their integration efforts? Without this understanding, we cannot adequately support teachers in this complex work or learn from successful practices.

Second, community elders, the primary custodians and transmitters of indigenous knowledge, have rarely been asked about their perspectives on formal education's engagement with their knowledge. How do they perceive schools' incorporation or exclusion of indigenous knowledge? What do they observe happening to traditional knowledge transmission as children spend increasing time in formal education? What concerns or hopes do they hold regarding the relationship between indigenous and scientific knowledge? How do they view their potential role in education? What kinds of knowledge do they consider appropriate or inappropriate for school inclusion? These perspectives are essential for ensuring that integration efforts are culturally appropriate, respectful, and aligned with community values.

Third, learners' experiences of navigating between indigenous and scientific knowledge systems remain underexplored. When teachers attempt integration, how do learners make sense of learning that engages both knowledge systems? Do they experience contradiction or complementarity? How does integration affect their engagement with biology? Does it influence their sense of cultural identity or belonging? What do they find valuable, confusing, or problematic about integration efforts? Understanding learners' meaning-making processes is crucial for designing effective integration approaches.

These knowledge gaps have practical consequences. Teacher education programs lack empirical grounding for preparing teachers to integrate knowledge systems. Curriculum developers cannot design appropriate materials and guidelines without understanding implementation realities. Policy makers promote integration without evidence of what works, what doesn't, and why. Communities remain disconnected from educational processes that affect the transmission and valuation of their knowledge. Ultimately, learners receive biology education that may fail to achieve the relevance, engagement, and cultural affirmation that integration promises.

This research addresses these gaps by asking; How do Zambian biology teachers and community elders experience and navigate the integration of indigenous and scientific knowledge, and how do learners make meaning when engaging with both knowledge systems?

1.3. Purpose and Objectives of the Study

1.3.1. Research Purpose

The primary purpose of this study is to develop deep, contextual understanding of how Zambian biology teachers and community elders experience and navigate the integration of indigenous and scientific knowledge systems, and how learners make meaning when engaging with both knowledge systems. Through narrative inquiry that prioritizes participants lived experiences and sense-making, this research seeks to

uncover the pedagogical strategies, epistemological negotiations, challenges, supports, and outcomes associated with integration efforts in authentic educational contexts.

1.3.2. Research Objectives

To achieve this purpose, the study pursues the following objectives:

1.3.2.1. Main Objective

To explore and understand how Zambian biology teachers and community elders experience and navigate the integration of indigenous and scientific knowledge systems in secondary biology education, and to examine the meaning-making processes that learners employ when engaging with both knowledge systems.

1.3.2.2. Sub-objectives

a) To explore and document the lived experiences of biology teachers who integrate indigenous and scientific knowledge in their teaching, including the pedagogical strategies they employ, the community tensions they navigate, and the factors that support or constrain their efforts.

b) To examine how learners experience and make meaning of biology education that engages both indigenous and scientific knowledge systems, including how they navigate apparent contradictions, what they find engaging or confusing, and how integration affects their sense of identity and belonging.

c) To identify broader patterns in teacher attitudes and practices regarding indigenous knowledge integration through quantitative survey data that contextualizes the qualitative findings.

1.4. Research Questions

This narrative inquiry is guided by one overarching research question and three subsidiary questions that address specific dimensions of the integration phenomenon.

1.4.1. Main Research Question

How do Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge in biology education, and how do learners make meaning when engaging with both knowledge systems?

1.4.2. Subsidiary Research Questions

a) What are the lived experiences of biology teachers who integrate indigenous and scientific knowledge in their teaching?

b) How do learners experience and make meaning of biology education that engages both
indigenous and scientific knowledge systems?

c) What broader patterns exist in teacher attitudes and practices regarding indigenous knowledge integration across the wider sample?

1.5. Significance and Rationale

This research holds significance for multiple stakeholders and contributes to several interconnected domains of knowledge and practice.

1.5.1. Theoretical Significance

Theoretically, this study contributes to growing international scholarship on epistemological pluralism in science education; the recognition that multiple legitimate ways of knowing exist and can be productively engaged in educational settings. By examining how teachers and learners actually navigate epistemological differences in authentic contexts, the research provides empirical grounding for theoretical discussions that often remain abstract.

The study also contributes to decolonizing science education scholarship by centring African perspectives and experiences. This challenges the dominance of Western-centric research frameworks demonstrating that knowledge production about science education need not originate exclusively from the Global North. The narrative inquiry approach honours African traditions of storytelling and oral knowledge transmission while producing rigorous scholarly insights. Additionally, the research advances understanding of culturally-responsive pedagogy specifically in science education. While culturally-responsive teaching has been extensively theorized, its application to science, where questions of epistemology and universal versus culturally-specific knowledge arise, requires particular attention. This study provides concrete examples of what culturally-responsive biology teaching looks like in practice.

1.5.2. Practical Significance

For practicing biology teachers, this research offers invaluable insights from colleagues who have navigated integration challenges. Therefore, this potentially inspires and guides others to attempt similar approaches. The documentation of specific pedagogical strategies, responses to tensions, and outcomes provides practical knowledge that can inform teaching practice. Teachers may find validation for their own integration efforts and encouragement that they are not alone in facing these challenges.

Regarding teacher educators and professional development providers, the findings illuminate what knowledge and skills teachers need to integrate indigenous and scientific knowledge effectively. This can inform pre-service teacher education programs, in-service professional development workshops, and the development of teaching resources and materials. Understanding the challenges teachers face enables more targeted and effective support.

Concerning curriculum developers and policy makers, the research provides evidence regarding the feasibility and outcomes of integration in authentic educational contexts, moving beyond aspirational policy statements to implementation realities. The findings can inform revision of curriculum documents, development of assessment practices that value both knowledge systems, and creation of enabling policy environments for integration.

About community elders and leaders, the research creates space for their voices in educational discourse from which they are typically excluded. The findings can inform community decisions about engagement with schools and negotiation of how indigenous knowledge is incorporated. The research may also strengthen arguments for community involvement in education.

And for learners, although they are not the primary audience for this academic work, the ultimate significance lies in potential improvements to their educational experiences; greater relevance, engagement, cultural affirmation, and holistic understanding of their biological world.

1.5.3. Contextual Significance

Within the Zambian educational context specifically, this research addresses a timely need. As the country continues developing its education system with goals of improved quality, equity, and relevance, understanding how to meaningfully integrate indigenous knowledge represents an important dimension of this development. The research can inform national conversations about curriculum reform, teacher development, and school-community partnerships.

The study also has potential significance beyond Zambia to other African contexts and post-colonial nations facing similar challenges of balancing global knowledge with local cultural heritage in education. While findings will be specific to Zambian contexts, the methodological approaches and conceptual insights may transfer to other settings.

1.5.4. Contribution to Social Justice

At a fundamental level, this research contributes to educational justice by working toward more equitable recognition and valuing of different knowledge systems. The historical marginalization of indigenous knowledge in formal education represents an ongoing legacy of colonialism that perpetuates hierarchies of knowledge and culture. By documenting successful integration efforts and amplifying voices of community elders, the research challenges these hierarchies and models more respectful and inclusive approaches to knowledge.

For learners from indigenous communities, education that honours their cultural knowledge alongside scientific knowledge offers possibilities for maintaining strong cultural identities. This integration counters assimilationist educational models that require learners to abandon their cultural heritage to succeed academically.

1.6. Scope and Limitations of the Study

1.6.1. Scope

This study focuses specifically on biology education at the secondary school level in selected schools within Zambia. The geographic scope includes both urban and rural schools to capture diverse contexts, though the specific selection will be detailed in Chapter Three. The research examines integration of indigenous knowledge related to biology topics, including medicinal plants, traditional agriculture, local ecosystems, animal behaviour, and health practices, rather than indigenous knowledge more broadly.

Participant groups include practicing biology teachers who have experience with or interest in integration efforts, community elders recognized as knowledge holders regarding traditional ecological and health knowledge, and secondary school learners who have experienced some integration attempts in their biology education. The study

employs a mixed-methods design with emphasis on qualitative narrative inquiry supplemented by quantitative survey data.

Temporally, the research captures experiences and perspectives at a particular moment (2025-2026), recognizing that both formal education and indigenous knowledge systems are dynamic and evolving. The study does not attempt longitudinal tracking of changes over time, though participants may reflect on changes they have observed.

1.6.2. Limitations

Several limitations constrain this research. First, as narrative inquiry focused on lived experience, the study prioritizes depth over breadth. The relatively small number of participants in the qualitative component means findings may not be statistically generalizable to all Zambian biology teachers, elders, or learners. However, the rich, contextual insights generated through narrative inquiry offer different but equally valuable forms of knowledge, what Stake (1995) calls "naturalistic generalization" based on experiential resonance rather than statistical probability.

Second, the study relies primarily on self-reported experiences and perceptions gathered through interviews and surveys rather than extensive classroom observations. While some observational data will supplement interviews, resource constraints prevent extended ethnographic presence in multiple schools. This means the research captures how participants narrate and make sense of their experiences rather than providing comprehensive documentation of actual classroom practices.

Third, language may present limitations. While the researcher is fluent in English and several Zambian languages, some shades of meaning may be lost in translation, particularly when elders discuss indigenous knowledge concepts that may lack direct English equivalents. Efforts will be made to conduct interviews in participants' preferred languages and to carefully negotiate meanings across languages.

Fourth, the researcher's own positionality, as a Zambian biology educator with particular cultural background and educational experiences, inevitably shapes the research process, from question formulation through data interpretation. While this insider status provides important contextual knowledge and cultural competence, it may also create blind spots. Reflexivity practices detailed in Chapter Three will address this limitation.

Fifth, the research focuses on integration efforts within existing formal education structures rather than examining alternative or community-based education models. This focus reflects the reality that most Zambian children's primary educational experience occurs in formal schools, but it may overlook other valuable approaches to knowledge transmission and integration.

Finally, the study cannot address all dimensions of indigenous knowledge integration. It focuses specifically on biology education rather than science education more broadly, and examines integration at secondary rather than primary level. The particular challenges and opportunities at other levels and in other subjects may differ.

1.6.3. Delimitations

Certain boundaries have been deliberately chosen to make the study manageable and focused. The research examines secondary rather than primary education because biology as a distinct subject emerges at secondary level. It focuses on teachers, elders, and learners rather than including administrators, parents, or policy makers, though these stakeholders certainly have relevant perspectives. The study examines integration efforts within existing curriculum structures rather than proposing entirely new curriculum designs. These delimitations allow for adequate depth of inquiry within available resources while still addressing the core research questions.

1.7. Definition of Key Terms

For clarity and consistency, key terms used throughout this dissertation are defined as follows:

- Indigenous Knowledge (IK)

Local, place-based knowledge developed by communities through generations of experience, observation, and experimentation with their specific environments. In the Zambian context, this encompasses traditional ecological knowledge, medicinal plant knowledge, agricultural practices, and understanding of local organisms and ecosystems.

- Scientific Knowledge (SK)

Knowledge about the natural world developed through systematic observation, experimentation, and reasoning according to the methods and epistemology of Western modern science. In this study, scientific knowledge refers specifically to biology content as represented in formal curriculum, textbooks, and standardized assessments.

- Integration

The pedagogical process of bringing together indigenous and scientific knowledge in biology education in ways that respect both knowledge systems while enabling learners to engage with and learn from both. Integration may take various forms, from using local examples to illustrate scientific concepts to comparing different explanatory frameworks for phenomena.

- Culturally-Responsive Pedagogy

Teaching approaches that recognize, respect, and incorporate learners' cultural backgrounds, knowledge, and experiences into educational processes. In science education specifically, this involves connecting scientific concepts to learners' cultural contexts and validating community knowledge.

- Narrative Inquiry

A qualitative research methodology that examines human experience through the stories people tell, recognizing that narrative is a fundamental way humans make

meaning of their lives. Narrative inquiry involves collecting stories through interviews or other means, analyzing these stories for themes and meanings, and re-presenting findings in narrative form.

- Community Elders

Individuals recognized within their communities as custodians and transmitters of traditional knowledge, typically but not exclusively older adults who have acquired extensive knowledge through experience and mentorship and who play or have played roles in teaching younger generations.

- Epistemology

The branch of philosophy concerned with the nature, sources, and limits of knowledge; essentially theories about what counts as knowledge and how knowledge is validated. Different epistemologies underlie indigenous and scientific knowledge systems.

- Decolonization (of education)

The process of critically examining and dismantling colonial legacies in educational systems, including challenging the dominance of Western knowledge, validating indigenous knowledge systems, and centring African perspectives and needs in educational decisions.

- Pedagogical Content Knowledge (PCK)

The specialized knowledge teachers develop about how to teach particular content to particular learners, including knowledge of effective representations, examples, analogies, and strategies for addressing learner difficulties.

1.8. Organization of the Paper

This paper is organized into five chapters that progressively develop the research from conceptual foundations through methodological approach to findings and implications.

a) Chapter One - Introduction

It has established the research foundation by presenting the background and context for studying indigenous knowledge integration in Zambian biology education. It articulates the specific research problem and gaps in current understanding, stating the research purpose and objectives, posing the guiding research questions, discussing the significance of the study for various stakeholders, outlining scope and limitations, and defining key terms.

b) Chapter Two - Literature Review

It examines existing scholarship relevant to this research across several domains; theoretical frameworks for understanding knowledge systems and their integration, international and African perspectives on indigenous knowledge in science education, research on culturally-responsive science pedagogy, studies of teacher knowledge and practice regarding integration, community perspectives on indigenous knowledge and

education, and learner experiences of engaging with multiple knowledge systems. This chapter identifies what is already known, reveal remaining gaps that this study addresses, and establish the theoretical framework guiding the research.

c) Chapter Three - Research Methodology

This chapter details the methodological approach, including philosophical foundations and justification for the descriptive and exploratory mixed-methods design anchored in narrative inquiry, description of the research setting and context in Zambia, participant selection strategies and criteria. Additionally, it stipulates data collection methods including interview protocols, focus group guidelines, observation frameworks, and survey instruments. Further, it outlines data analysis procedures for both qualitative and quantitative methods, strategies for ensuring trustworthiness and credibility, ethical considerations and protections for participants, and researcher positionality and reflexivity.

d) Chapter Four - Presentation and Analysis of Findings

The chapter presents the research results organized around the research questions, including narrative accounts co-constructed from teacher, elder, and learner interviews, thematic analysis of focus group discussions and observations. It also displays survey results showing broader patterns in teacher attitudes and practices, and integrated analysis that brings together multiple data sources to develop comprehensive understanding of the integration phenomenon.

e) Chapter Five - Discussion, Conclusions and Recommendations

This chapter interprets the findings in relation to existing literature and theoretical frameworks, discuss implications for theory and practice and presents conclusions regarding the research questions. It further acknowledges limitations and their implications, offer recommendations for curriculum development, teacher education, policy, and practice. It finally suggests directions for future research, and provide closing reflections on the contribution of this work to more equitable and culturally-responsive biology education in Zambia.

1.9. Chapter Summary

This chapter has introduced a narrative inquiry into how Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge systems in secondary biology education. The research responds to a critical gap asserting that despite policy commitments to integration and recognition of its potential benefits, we lack deep understanding of the lived experiences of those who attempt integration, the perspectives of community knowledge holders, and the sense-making processes of learners engaging with both knowledge systems. The study is grounded in the recognition that Zambian communities possess profound ecological knowledge developed over generations, yet formal biology education has historically marginalized this knowledge, creating disconnections between learners' cultural identities and their schooling. While some teachers courageously bridge these worlds, their stories and strategies remain largely undocumented and unsupported. Community elders' wisdom about their knowledge and its relationship to formal education remains unheard in educational discourse. Learners' experiences of navigating between knowledge systems remain underexplored.

Through mixed-methods research prioritizing qualitative narrative inquiry, this study will gather and analyze the stories of biology teachers, community elders, and learners to develop rich, contextual understanding of integration as a lived phenomenon. The research pursues three specific objectives through one main research question and several subsidiary questions that address teacher experiences, elder perspectives, learner meaning-making, and broader patterns across a wider sample.

The significance of this work extends across multiple domains; contributing to theoretical understanding of epistemological pluralism and culturally-responsive pedagogy. It provides practical insights for teachers, teacher educators, curriculum developers, and policy makers centring African perspectives in science education scholarship and ultimately working toward more equitable, relevant, and culturally-affirming biology education for Zambian learners. The next chapter examines existing literature on indigenous knowledge in science education, establishing the theoretical framework and scholarly context within which this research is positioned.

II. Chapter Two - Literature Review

2. Introduction

This chapter examines the scholarly literature relevant to understanding the integration of indigenous and scientific knowledge in biology education. The review serves multiple purposes. It establishes the theoretical frameworks that guide this research, synthesizes what is currently known about indigenous knowledge integration in science education, identifies gaps in existing scholarship that this study addresses. Additionally, positions the current research within broader academic conversations about culturally-responsive pedagogy, epistemological pluralism, and decolonizing education.

The literature review is organized into eight main sections. Following this introduction, section 2.1 presents the theoretical framework that guides the study, drawing on theories of epistemological pluralism, cultural-historical activity theory, and post-colonial perspectives on education. Section 2.2 examines scholarship on indigenous knowledge systems themselves; their characteristics, epistemological foundations, and contemporary challenges. Section 2.3 reviews international and African research on indigenous knowledge in science education, including debates about integration approaches and documented outcomes. Section 2.4 focuses specifically on culturally-responsive pedagogy in science education, exploring how scholars have conceptualized and studied teaching that honours learners' cultural backgrounds while developing scientific understanding.

Section 2.5 examines research on teacher knowledge and practice regarding integration, including studies of teacher beliefs, pedagogical content knowledge, and the challenges faced when attempting to bridge knowledge systems. Section 2.6 reviews the limited but growing literature on community perspectives regarding indigenous knowledge and formal education, highlighting the voices often marginalized in educational research. Section 2.7 explores what is known about learner experiences and meaning-making when engaging with multiple knowledge systems, including studies of identity, engagement, and conceptual understanding. The chapter concludes with section 2.8,

which synthesizes key themes across the literature and articulates how this study addresses identified gaps.

The review draws primarily on peer-reviewed scholarship from science education, indigenous studies, African education research, and related fields. It encompasses both theoretical and empirical work, with particular attention to studies conducted in African contexts, though relevant international scholarship is also included. The search strategy involved systematic exploration of major educational databases including Educational Resources Information Centre (ERIC), Web of Science, and Google Scholar, using search terms such as 'indigenous knowledge,' 'science education,' 'culturally-responsive pedagogy,' 'traditional ecological knowledge,' 'Africa,' 'biology education,' 'integration,' and 'epistemology'. Additional sources were identified through citation tracking and consultation with key journals in science education and indigenous studies.

Throughout the review, critical attention is given to questions of epistemology; how different scholars conceptualize knowledge, knowing, and the relationship between indigenous and scientific knowledge systems. These epistemological considerations are fundamental to understanding debates about integration and to framing the current study's approach. The review also attends to issues of power, voice, and representation, recognizing that much scholarship about indigenous knowledge has historically been conducted by non-indigenous researchers using Western frameworks, though this is gradually changing as indigenous scholars increasingly lead research in this domain.

2.1. Theoretical Framework

This study is grounded in an integrated theoretical framework that draws on three complementary perspectives: epistemological pluralism theory, cultural-historical activity theory, and post-colonial theory as applied to education. Together, these frameworks provide conceptual tools for understanding how different knowledge systems can coexist and interact in educational settings, how teaching and learning are fundamentally cultural activities shaped by historical contexts, and how contemporary education in post-colonial nations continues to navigate legacies of colonialism. This section explicates each theoretical perspective and shows how they combine to frame the research.

2.1.1. Epistemological Pluralism

Epistemological pluralism, as articulated by scholars such as Cobern and Loving (2001), Ogawa (1995), and Carter (2004), rejects the notion that Western science represents the only valid way of knowing about the natural world. Instead, it recognizes that multiple epistemologies, different theories about what constitutes knowledge and how knowledge is validated, can coexist and each offers legitimate insights within particular contexts and for particular purposes. This perspective challenges what Harding (1998) calls the one true science narrative that has dominated science education.

Ogawa (1995) introduced the concept of 'multi-science perspective, arguing that science should be understood as a rational perceiving of reality that exists in multiple cultural forms, not exclusively in Western modern science. From this view, indigenous

knowledge systems represent alternative sciences; systematic, empirically-grounded ways of understanding nature that employ different but equally valid methods of observation, experimentation, and knowledge validation. Cobern and Loving (2001) similarly argue for sensible multiculturalism in science education, which recognizes cultural diversity in ways of knowing while still maintaining standards for empirical adequacy and logical coherence.

Crucially, epistemological pluralism does not imply uncritical relativism; the notion that all knowledge claims are equally valid regardless of evidence or reasoning. Rather, it suggests that different knowledge systems can be evaluated according to their own internal standards of rigor while also being respected as culturally embedded ways of making sense of experience. Snively and Corsiglia (2001) demonstrate this in their analysis of indigenous science in the Pacific Northwest, showing how traditional knowledge systems employ systematic observation, hypothesis testing, and knowledge revision, hallmarks of scientific thinking, while operating within different metaphysical frameworks than Western science.

For this study, epistemological pluralism provides justification for taking indigenous knowledge seriously as a legitimate knowledge system worthy of inclusion in biology education, not merely as cultural enrichment or historical curiosity. It also frames integration as involving genuine dialogue between knowledge systems rather than simply subordinating indigenous knowledge to scientific frameworks. However, epistemological pluralism alone does not address the practical and pedagogical questions of how such dialogue occurs in classrooms, which leads to the second theoretical perspective.

2.1.2. Cultural-Historical Activity Theory

Cultural-historical activity theory (CHAT), developed by Vygotsky, Leont'ev, and Engeström, provides a framework for understanding teaching and learning as culturally mediated activities embedded in specific historical contexts and social systems. CHAT directs attention to the tools (both material and symbolic), rules, community structures, and divisions of labour that shape how people engage in activities such as teaching biology or learning about medicinal plants.

Engström's (2001) expanded model of activity systems is particularly useful for analyzing the integration of indigenous and scientific knowledge in schools. This model conceptualizes activity as involving subjects (teachers, learners, elders) who act on objects (knowledge, understanding) using mediating tools (language, concepts, physical materials) within community contexts governed by rules (curriculum requirements, cultural protocols) and characterized by particular divisions of labour (who has authority to teach what?). Contradictions within and among activity systems drive change and learning.

Applied to this research, CHAT illuminates how biology teaching represents an activity system shaped by the historical development of formal education in Zambia, the 'cultural' tools and practices inherited from colonial education, and contemporary tensions between curriculum mandates and community knowledge. When teachers attempt to integrate indigenous knowledge, they are introducing elements from a

different activity system, traditional knowledge transmission, that operates according to different rules, employs different facilitating tools, and involves dissimilar divisions of labour. The contradictions that arise may be productive sites for learning and transformation. However, they also create challenges that teachers must navigate.

Roth and Lee (2007) demonstrate CHAT's utility for understanding science education in culturally diverse contexts, showing how it helps explain why simply adding multicultural content to Western-style science teaching often fails; because the deeper cultural-historical contexts and activity structures remain unchanged. For indigenous knowledge integration to be meaningful, it requires examining and potentially transforming the activity system of science education itself, not just adding new concepts and content.

2.1.3. Post-colonial Theory in Education

Post-colonial theory, as developed by scholars such as Said (1978), Spivak (1988), and Bhabha (1994) and applied to education by Tikly (1999), Crossley and Tikly (2004), and others, provides critical tools for understanding how contemporary education in former colonies continues to be shaped by colonial legacies. Central concepts include the examination of power relations in knowledge production, the persistence of colonial discourses that position Western knowledge as superior, the marginalization of colonized peoples' epistemologies, and the complex negotiations of identity and belonging in labour post-colonial contexts.

In science education specifically, post-colonial theorists argue that the dominance of Western scientific knowledge in curricula represents a continuation of colonial patterns that devalued indigenous knowledge systems. McKinley and Stewart (2012) demonstrate how science education in New Zealand, even after decades of independence, perpetuated colonial hierarchies. They assert that perpetuation is seen through curriculum content, pedagogical approaches, and assessment practices that privileged Western ways of knowing while marginalizing Māori knowledge.

The concept of epistemological violence, the ways formal education can damage or destroy indigenous knowledge systems, is particularly relevant. As Battiste (2013) argues, when schools teach that only Western science constitutes valid knowledge about nature, they actively undermine indigenous knowledge systems, leading to knowledge loss and cultural alienation. This violence is often invisible because it operates through seemingly neutral curriculum and pedagogical choices. However, post-colonial theory also emphasizes agency and resistance. Bhabha's (1994) concept of hybridity recognizes that colonized peoples do not simply accept or reject colonial impositions but creatively negotiate and transform them. This creates new cultural forms that blend elements from different traditions. Applied to education, this suggests possibilities for genuinely hybridized pedagogy that honours both indigenous and Western knowledge without simply reproducing colonial hierarchies.

For this research, post-colonial theory provides critical perspective on why integration matters. It is not simply about pedagogical effectiveness but about decolonizing education and challenging persistent colonial hierarchies. It also frames the research itself as a political act that can either reproduce colonial patterns of knowledge

extraction (if conducted extractively by researchers) or contribute to decolonization (if conducted collaboratively with attention to power and voice). The inclusion of community elder perspectives in this study reflects post-colonial commitments to centring marginalized voices.

2.1.4. Synthesizing the Framework

These three theoretical perspectives combine to create an integrated framework for understanding indigenous knowledge integration in biology education. Epistemological pluralism establishes the philosophical legitimacy of integration; that indigenous and scientific knowledge systems both offer valid insights and deserve respectful engagement. Cultural-historical activity theory provides tools for analyzing the practical, situated challenges of integration; understanding teaching and learning as culturally embedded activities shaped by tools, rules, and community contexts. Post-colonial theory situates integration within histories of colonialism and ongoing power relations, reminding us that curriculum choices are never politically neutral.

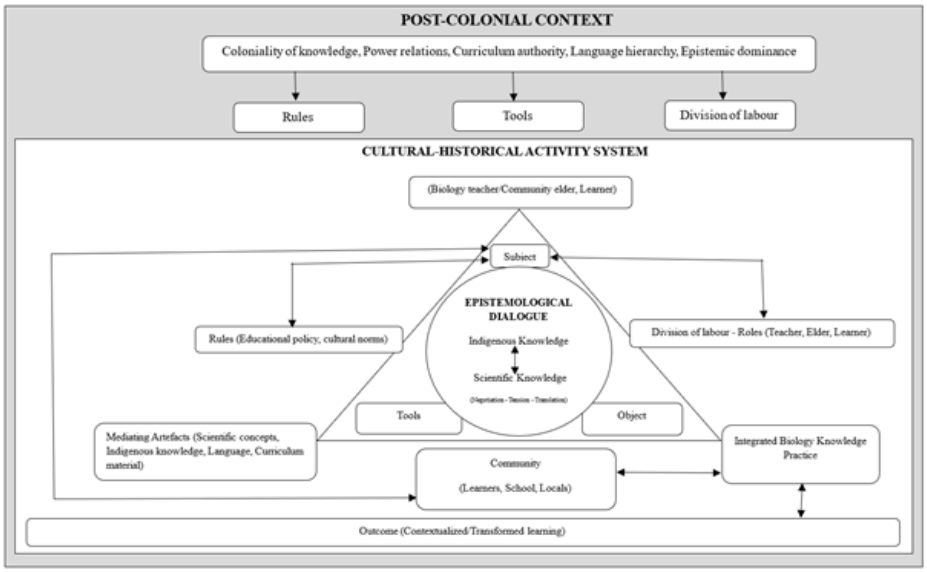

Figure 1: Synthesized Theoretical Framework - (Source: Author)

Together, these frameworks suggest that successful integration requires: (1) genuine respect for indigenous knowledge as an epistemologically legitimate system, not merely cultural decoration; (2) attention to the cultural-historical contexts and activity structures of both traditional knowledge transmission and formal schooling; (3) critical awareness of colonial legacies and power dynamics; and (4) commitment to transforming education in ways that honour multiple ways of knowing and support learners' complex cultural identities.

This integrated framework guides the research design, data analysis, and interpretation of findings. It shapes the research questions by directing attention to teachers' navigation of epistemological tensions, the cultural-historical contexts that enable or

constrain integration, and the perspectives of community elders whose knowledge has been historically marginalized. It informs the methodological choice of narrative inquiry, which aligns with post-colonial commitments to centring participants' voices and with CHAT's emphasis on understanding activity in context. The framework will be revisited in Chapter Five when interpreting findings and discussing implications.

2.2. Indigenous Knowledge Systems

This section examines scholarly literature on indigenous knowledge systems themselves, their characteristics, epistemological foundations, knowledge domains, transmission processes, and contemporary challenges. Understanding indigenous knowledge on its own terms, rather than only in relation to Western science, is essential groundwork for meaningful integration.

2.2.1. Defining and Characterizing Indigenous Knowledge

Indigenous knowledge has been variously termed traditional knowledge, local knowledge, traditional ecological knowledge (TEK), or indigenous knowledge systems (IKS). While definitions vary, most scholars emphasize several common characteristics. Berkes (2018) defines TEK as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission". It is about the relationship of humans with one another and with their environment. This definition highlights the experiential, adaptive and culturally transmitted nature of indigenous knowledge.

Indigenous knowledge is fundamentally place-based, developed through intimate, sustained engagement with specific landscapes and ecosystems over multiple generations. As Battiste and Henderson (2000) explain, it emerges from peoples' direct experience of their environments and reflects deep understanding of local ecology, seasonal patterns, plant and animal behaviours, and resource management. This place-based character contrasts with Western science's emphasis on universal principles that apply across contexts.

Indigenous knowledge is characteristically holistic, integrating domains that the Western world thought separate. It encompasses ecological systems, medicinal study, agricultural practices and social knowledge that form interconnected wholes. Cajete (2000) describes indigenous science as sophisticated comprehensive worldviews that encompass not just empirical knowledge but also values, relationships, and responsibilities. Knowledge of medicinal plants, for example, cannot be separated from spiritual relationships with those plants or ethical guidelines for harvesting. This holistic integration reflects underlying metaphysical assumptions about the interconnectedness of all aspects of reality. Cajete challenges the assumption that Western science is the only valid form of scientific inquiry.

Indigenous knowledge is transmitted primarily through oral traditions, experiential learning, and apprenticeship relationships rather than written texts. Storytelling, proverbs, songs, rituals, and direct observation serve as pedagogical tools. As Aikenhead and Michell (2011) emphasize, knowledge is not abstracted from its cultural and relational contexts but remains embedded in stories and practices that reinforce cultural values and community bonds. However, although this oral-experiential

transmission creates strong intergenerational connections, it also makes knowledge vulnerable when these transmission pathways are disrupted.

Importantly, indigenous knowledge is dynamic and adaptive, not static tradition. Communities continuously observe, experiment, and incorporate new information, adjusting practices based on outcomes. Agrawal (1995) challenges romantic notions of indigenous knowledge as unchanging ancient wisdom. He argues that treating indigenous knowledge and Western science as completely distinct systems reinforces the very hierarchies' scholars seek to dismantle. The dynamism of indigenous knowledge systems parallels science's self-correcting character, though operating through different institutional structures.

2.2.2. Epistemological Foundations

The epistemological foundations of indigenous knowledge systems differ significantly from Western scientific epistemology, though important commonalities also exist. Understanding these differences and similarities is crucial for meaningful integration attempts.

Indigenous epistemologies typically emphasize relational ways of knowing. As Wilson (2008) explains in his articulation of indigenous research paradigms, knowledge emerges through relationships; with land, with other beings, with ancestors, with community. He argues that research is not merely a technical process of data collection and analysis, but rather a relational and ethical ceremony that binds researcher, participants, land and knowledge. Reality is understood as fundamentally relational rather than consisting of discrete, independent objects. This contrasts with Western science's subject-object dualism, where knowers are separate from and objective about what they study.

Many indigenous knowledge systems operate within what Kawagley (2006) calls 'participatory' or 'subjective-objective' epistemologies that recognize knowers as embedded within and related to what they know. Knowledge claims are validated not only through empirical observation but also through spiritual experience, dreams, and intuitive understanding. This does not mean indigenous knowledge rejects empirical evidence, careful observation is central, but it recognizes multiple sources and types of knowing beyond the purely empirical.

Indigenous epistemologies often emphasize collective knowledge developed and held communally rather than individual expertise. As Simpson (2004) describes in her analysis of Nishnaabeg knowledge (North America), understanding emerges through community practices and collective experience over time rather than individual genius or discovery. While particular individuals may have specialized knowledge, that knowledge belongs to and serves the community, and its validity is confirmed through communal use and transmission across generations.

Responsibility and reciprocity are epistemological principles, not just ethical add-ons. Kimmerer (2013), a botanist and member of the Citizen Potawatomi Nation, articulates how indigenous knowledge involves reciprocal relationships with the beings one knows. He demonstrates how indigenous teachings and empirical science can coexist

without erasing their differences. Despite these differences, important similarities exist between indigenous and scientific ways of knowing. Both emphasize careful observation, pattern recognition, hypothesis formation and testing, and knowledge revision based on outcomes. Snively and Corsiglia (2001) document sophisticated indigenous ecological understanding developed through systematic observation and logical inference. The differences lie more in metaphysical frameworks and institutional structures than in the basic cognitive processes of observation and reasoning.

2.2.3. Indigenous Ecological Knowledge

Within the broader category of indigenous knowledge, traditional ecological knowledge (TEK) is particularly relevant to biology education. TEK encompasses understanding of local ecosystems, plant and animal species, ecological relationships, sustainable resource management, and environmental change. Numerous studies document the sophistication and accuracy of indigenous ecological knowledge. Berkes (2018) systematically examines how indigenous knowledge systems contribute to biodiversity conservation, resource management and sustainability. This knowledge often exceeds what Western science knows about the same systems, particularly regarding local variations and long-term ecological patterns.

Turner et al. (2000) document the extensive botanical knowledge of indigenous peoples in the Pacific Northwest, including identification of over 300 plant species, understanding of their ecological requirements and distributions, knowledge of edible and medicinal uses, and sustainable harvesting practices. Similarly, Chinsembu (2016) reviews ethnobotanical knowledge in Southern Africa - Zambia, documenting rich traditions of plant use for medicine, food and materials.

Indigenous agricultural knowledge represents another well-documented domain. Traditional farming systems often demonstrate sophisticated understanding of soil ecology, plant genetics, pest dynamics, and climate adaptation. Altieri (2004) shows how traditional polyculture systems in Latin America, Africa, and Asia achieve ecological sustainability and productivity through intensive knowledge of plant relationships, nutrient cycling, and pest management; knowledge developed over millennia of experimentation.

Critically, TEK often includes understanding that Western science is only beginning to recognize. For example, indigenous fire management practices in Australia, long dismissed by colonial authorities, are now recognized as essential for ecosystem health and biodiversity (Bird et al., 2008). Traditional phenological knowledge, understanding of seasonal timing of biological events, provides crucial data for understanding climate change impacts (Moller et al., 2004).

However, indigenous ecological knowledge faces threats from multiple sources. Environmental degradation reduces the resource base that knowledge addresses. Social and economic changes, including formal education that takes children away from land-based learning, disrupt knowledge transmission. Biopiracy, appropriation of indigenous knowledge by pharmaceutical companies and others without permission or benefit-sharing, creates distrust. And marginalization of indigenous knowledge in formal

education reinforces perceptions among youth that traditional knowledge is irrelevant or inferior.

2.2.4. Indigenous Knowledge in African Contexts

While much literature on indigenous knowledge comes from North American, Australian, and New Zealand contexts, growing scholarship addresses African indigenous knowledge systems. This work challenges monolithic notions of 'African indigenous knowledge' by documenting diversity across the continent while also identifying common themes.

Odora Hoppers (2002) provides comprehensive analysis of indigenous knowledge systems in Africa, arguing they represent sophisticated epistemologies marginalized by colonial and post-colonial education systems. She documents knowledge in domains including medicine, agriculture, natural resource management, conflict resolution, and education. She shows how this knowledge systems supported flourishing communities before colonial disruption and continue to serve many Africans despite official neglect. In Southern Africa specifically, where Zambia is located, Shizha (2013) examines how indigenous knowledge systems have been systematically excluded from education despite their continued relevance to community life. He documents knowledge in areas such as traditional medicine, where healers possess detailed understanding of medicinal plants and treatments; agriculture. Small-holder farmers employ complex knowledge of local crop varieties, soil management, and climate adaptation; and natural resource management, including knowledge of wildlife, water sources, and sustainable harvesting.

Mawere (2015) explores indigenous environmental knowledge in Zimbabwe, showing parallels to Zambian contexts. He contends that local forms of knowledge can act as tools for enriching the teaching-learning processes. For instance, curriculum grounded in learners' everyday contexts can make learning more meaningful and relevant.

Regarding knowledge transmission, Serpell (2011) analyses indigenous education in Zambia specifically, showing how traditional socialization involved experiential learning, apprenticeship, storytelling, and participation in community activities. Children learned through observation and guided practice, with knowledge embedded in cultural contexts and relationships. This contrasts sharply with formal schooling's emphasis on abstract; decontextualized knowledge transmitted through texts and lectures.

African scholars increasingly critique how Western academia has approached indigenous knowledge; often extracting knowledge without giving back, studying communities as objects rather than partnering with them, and failing to recognize indigenous peoples as knowledge producers. Ndlovu-Gatsheni (2018) calls for 'epistemic freedom' that decolonizes knowledge production by centring African ways of knowing and being. This scholarship informs the current study's commitment to respectful engagement with community elders and collaborative knowledge construction.

2.3. Science Education and Indigenous Knowledge

This section reviews scholarship specifically addressing indigenous knowledge in science education contexts, examining debates about integration approaches, documented practices and outcomes, and perspectives from different global regions with particular attention to African research.

2.3.1. Theoretical Perspectives on Integration

Science education scholars propose various theoretical approaches for relating indigenous and scientific knowledge in educational settings. These approaches reflect different epistemological assumptions and have different pedagogical implications.

One approach, sometimes called the 'universalist' perspective, views science as culturally universal truth that all learners should master regardless of cultural background. From this view, indigenous knowledge may be acknowledged as cultural heritage but is not considered legitimate science education content. Stanley and Brickhouse (2001) critique this approach as perpetuating Western epistemological dominance and alienating learners from non-Western cultures.

A second approach, termed 'multicultural science education', incorporates indigenous knowledge as cultural enrichment that humanizes science and shows its cultural diversity. While more inclusive than strict universalism, critics argue this approach often treats indigenous knowledge as historical artifact rather than living epistemology, and may present indigenous examples without addressing epistemological differences. Aikenhead (2006) notes this can lead to superficial multiculturalism that adds content without transforming pedagogy.

A third approach advocates for 'parallel presentation' in science education, where indigenous and scientific knowledge are presented alongside each other with explicit comparison of their different explanatory frameworks. This approach, advocated by Snively and Corsiglia (2001), respects epistemological pluralism by maintaining integrity of both knowledge systems rather than forcing indigenous knowledge into scientific frameworks. However, it requires considerable teacher knowledge and skill to navigate comparisons without creating confusion or relativism.

A fourth approach, sometimes called 'integration', seeks to genuinely blend indigenous and scientific perspectives in ways that create new understanding transcending either system alone. McKinley and Stewart (2012) describe this as moving beyond either/or thinking to both/and approaches that recognize productive tensions between knowledge systems. However, critics worry this risks diluting both systems and question whether such synthesis is epistemologically coherent.

Aikenhead and Ogawa (2007) propose 'border crossing' as a useful metaphor, where learners learn to navigate between indigenous and scientific knowledge systems while maintaining integrity of both. This acknowledges that learners, especially indigenous learners, are already navigating multiple worlds and can develop capacities for code-switching and comparative thinking. Teaching becomes about facilitating smooth border crossings rather than forcing assimilation or maintaining rigid separations. These theoretical perspectives demonstrate ongoing debates about the very purpose and

nature of integration. Different purposes imply different pedagogical approaches and success criteria. This study's exploration of teacher practices and learner experiences can inform these theoretical debates with empirical evidence.

2.3.2. Integration Practices and Pedagogies

Empirical research documents various pedagogical approaches teachers use to integrate indigenous and scientific knowledge, with varying degrees of success and different outcomes.

One common approach uses indigenous examples to illustrate scientific concepts. For instance, teaching about plant adaptation by examining how local medicinal plants survive in specific environments, or teaching genetics using traditional crop varieties and selective breeding practices. Hewson and Ogunniyi (2011) studied South African teachers using this approach, finding it increased learner engagement and made abstract concepts more concrete, though it sometimes reduced indigenous knowledge to mere examples rather than alternative frameworks.

Another approach involves inviting community knowledge holders, elders, traditional healers, farmers, as guest speakers or co-teachers. George (1999) documents Alaskan science classes where elders taught alongside science teachers, sharing traditional ecological knowledge. Learners reported finding this meaningful and engaging, though logistical challenges and occasional tensions between elders and teachers emerged. Likewise, studies from New Zealand show benefits of kaitiaki (guardians) contributing Māori knowledge to science lessons (McKinley and Stewart, 2012).

Some teachers design inquiry investigations that engage both knowledge systems. For example, having learners investigate medicinal plant effectiveness using both traditional preparation methods and scientific testing, or comparing traditional and scientific weather prediction methods. Aikenhead (2001) describes Canadian classes where learners interviewed elders about traditional practices, then designed experiments to test underlying principles. This approach develops scientific skills while validating indigenous knowledge, though it requires carefully framing what constitutes valid evidence in each system.

Comparative approaches explicitly contrast indigenous and scientific explanations for phenomena, examining their similarities, differences, and complementarities. Ogunniyi (2007) developed the 'contiguity argumentation theory' approach in South Africa, where learners engage in structured argumentation comparing indigenous and scientific explanations, developing capacity to appreciate both while recognizing their different assumptions. Research shows this enhances critical thinking and epistemological awareness, though it demands sophisticated facilitation.

Place-based education represents another integration approach, where learning happens in community environments rather than just classrooms, engaging local ecosystems and community knowledge holders. Kawagley and Barnhardt (2005) describe Alaska Native science programs centered on traditional activities like fish camp, where scientific concepts are learned through indigenous practices. While resource-intensive, such approaches show strong outcomes for engagement, cultural identity, and learning.

Several studies identify factors supporting successful integration. These include teacher knowledge of both indigenous and scientific perspectives; respect for and relationships with community knowledge holders; curriculum flexibility allowing local adaptation; administrative support and adequate time; appropriate resources and professional development; and assessment practices that value both knowledge systems (Aikenhead, 2006; Lewthwaite and Renaud, 2009).

Challenges commonly reported include teachers' limited knowledge of indigenous traditions, especially when teaching in culturally different communities; time constraints and curriculum pressures; lack of resources and professional development; uncertainty about how to handle epistemological tensions; concerns about scientific rigor and examination preparation; and occasional resistance from parents or administrators who view indigenous knowledge as inappropriate for science class (Cronje et al., 2015).

2.3.3. Outcomes and Effects of Integration

Research examining outcomes of indigenous knowledge integration reveals varied findings across different contexts and measures.

Regarding academic achievement, results are mixed. Some studies show integration improves science learning outcomes, particularly for indigenous learners. For example, Rioux (2010) found that Canadian indigenous learners in programs integrating traditional knowledge showed higher science test scores than those in conventional programs. Similarly, Kidman et al. (2011) reported improved achievement in New Zealand science classes incorporating Māori knowledge. However, other studies find no significant achievement differences, suggesting integration's benefits may lie in other domains (Brayboy and Castagno, 2009).

Effects on engagement and motivation are more consistently positive. Multiple studies report that indigenous learners show increased interest, participation, and persistence in science when their cultural knowledge is included. Aikenhead (2006) documents how "culture-based science" approaches in Canada increased attendance and engagement among First Nations learners previously alienated from science. Similarly, Bang and Medin (2010) found that indigenous children showed greater curiosity and question-asking when learning science through culturally familiar contexts.

Integration affects cultural identity and belonging. Research shows that when schools validate indigenous knowledge, indigenous learners report feeling more comfortable, valued, and able to maintain cultural identities while pursuing science (Castagno and Brayboy, 2008). Conversely, science education that ignores or contradicts indigenous knowledge can create identity conflicts and force learners to choose between cultural belonging and academic success. Integration potentially resolves this forced choice, though only when done respectfully and substantially.

Epistemological development represents another outcome domain. Studies suggest that integration can develop learners' metacognitive awareness of how knowledge is constructed and validated. For instance, South African learners engaging with both indigenous and scientific knowledge developed more sophisticated understanding of

knowledge as constructed, contextual, and plural rather than viewing it as singular, absolute truth. This epistemological flexibility is increasingly recognized as valuable for navigating complex, multicultural societies.

However, research also documents potential negative outcomes from poorly implemented integration. Tokenistic inclusion that treats indigenous knowledge as inferior or primitive can reinforce rather than challenge marginalization (McKinley, 2007). Extracting indigenous knowledge from cultural contexts can distort or trivialize it (Nadasdy, 2003). And poorly facilitated comparisons between knowledge systems can create confusion or relativism if epistemological differences are not carefully navigated (Carter, 2004).

2.4. Teacher Knowledge and Practice

This section examines research on teacher knowledge, beliefs, and practices regarding indigenous knowledge integration, recognizing that teachers are central actors who mediate curricular intentions and learner experiences.

2.4.1. Teacher Knowledge for Integration

Integrating indigenous and scientific knowledge requires complex, multifaceted teacher knowledge beyond conventional science content knowledge. Scholars have attempted to characterize this knowledge using frameworks like pedagogical content knowledge (PCK) and its extensions.

Shulman's (1986, 1987) original PCK framework identified specialized knowledge needed for teaching particular content to particular learners, including: knowledge of effective representations, analogies, and examples; understanding of what makes concepts and topics easy or difficult for learners; and awareness of common misconceptions. Applied to integration, this suggests that teachers need PCK specific to teaching with multiple knowledge systems.

Aikenhead and Huntley (1999) propose 'cross-cultural science teaching' requires additional knowledge dimensions: understanding of indigenous knowledge systems relevant to science topics; awareness of cultural differences in communication styles, values, and ways of knowing; knowledge of learners' cultural backgrounds and community contexts; understanding of epistemological differences between knowledge systems; and skills for facilitating border crossing and comparative thinking. This represents a substantial expansion of conventional science teacher knowledge.

Van Driel et al. (2014) apply the 'knowledge quartet' framework to integration contexts, identifying four knowledge types: foundational knowledge (understanding both scientific and indigenous concepts); transformation knowledge (ability to represent concepts from both systems appropriately); connection knowledge (understanding relationships between knowledge systems and to learners' lives); and contingency knowledge (responding flexibly to learner questions and classroom situations that arise from engaging multiple systems).

Ethnographic studies reveal that successful integration also requires what González et al. (2005) call 'funds of knowledge'; understanding the cultural and cognitive resources

learners and communities possess. Teachers must view communities as knowledge-rich rather than deficit, recognizing parents and elders as experts. This challenges deficit perspectives common in teacher thinking about marginalized communities.

Research consistently shows most teachers lack adequate knowledge for integration. Studies across multiple contexts find teachers have limited understanding of indigenous knowledge systems, even when teaching in indigenous communities (Michie et al., 2018). They may hold stereotypical views of traditional knowledge as superstition or primitive practice rather than sophisticated epistemology. And they typically receive no preparation for integration in teacher education programs (Lewthwaite et al., 2013).

2.4.2. Teacher Beliefs and Attitudes

Teacher beliefs about the nature of science, indigenous knowledge, and the relationship between them significantly influence integration efforts. Research reveals diverse belief profiles.

Some teachers hold exclusivist beliefs, viewing science as universally true knowledge and indigenous knowledge as cultural belief or folklore without scientific validity. From this perspective, integration is inappropriate or impossible. Science must be kept pure from contamination by non-scientific content (Cobern and Loving, 2001). Teachers with these beliefs may comply minimally with integration process but resist substantive implementation.

Other teachers hold inclusive pluralist beliefs, recognizing indigenous and scientific knowledge as different but legitimate ways of knowing that can coexist and complement each other. These teachers view integration as both possible and valuable for various purposes. Research shows such beliefs correlate with greater integration efforts, though do not guarantee effective practice without adequate knowledge and skills (Ogunniyi, 2011).

Some teachers hold what might be called assimilationist beliefs; they value indigenous knowledge but primarily as a bridge or stepping stone toward scientific understanding. Indigenous examples may be used initially but are replaced once learners grasp ‘real scientific’ concepts. This reflects deficit thinking that sees indigenous knowledge as inferior but pedagogically useful for culturally different learners.

Few teachers articulate decolonial beliefs that would position indigenous knowledge as primary and Western science as an additional perspective. This likely reflects how teachers themselves were educated in systems privileging science, combined with institutional pressures to prepare learners for examinations focused on Western scientific knowledge.

Teacher beliefs are shaped by multiple factors. Personal cultural background and experiences matter. Teachers from indigenous communities or with significant exposure to traditional knowledge tend to hold more pluralist views (Aikenhead and Ogawa, 2007). Teacher education influences beliefs, though often reinforces science superiority rather than pluralism (Ninnes, 2000). The broader institutional context,

curriculum requirements, examination systems, administrator expectations, constrains what beliefs teachers can enact even when personally open to integration.

Importantly, beliefs are not necessarily consistent or static. Teachers may hold contradictory views, simultaneously valuing indigenous knowledge philosophically while viewing it as pedagogically impractical. Beliefs may also shift through experience; teachers attempting integration often develop more pluralist perspectives through the process (Cronje et al., 2015).

2.4.3. Pedagogical Practices

Research documenting actual integration practices reveals diversity in approaches, frequency and depth.

Regarding frequency, most studies find integration remains limited despite policy support. For example, Mokuku and Mokuku (2004) surveyed Lesotho science teachers and found fewer than 30% reported attempting integration, and those who did typically used occasional examples rather than systematic approaches. Similarly, Abonyi et al. (2014) found Nigerian teachers' integration attempts were sporadic and superficial. This pattern appears consistent across African contexts.

When teachers do integrate, practices vary in sophistication. Many employ what might be called 'additive' approaches; mentioning traditional practices or adding indigenous examples to otherwise conventional science teaching. This requires minimal pedagogical adjustment but also provides limited benefit beyond surface acknowledgment. Teachers report this feels safer than more substantial changes (Ninnes, 2000).

More sophisticated practices involve 'interactive' approaches where indigenous and scientific knowledge genuinely interact through comparison, investigation, or problem-solving. For example, teachers might have learners investigate why traditional practices work using scientific methods, or analyze both indigenous and scientific explanations for phenomena. These approaches require greater teacher knowledge and skill but show stronger learning outcomes (Aikenhead, 2001).

A few teachers employ what could be called 'transformative' approaches that fundamentally rethink science teaching around integration. Examples include extended projects addressing community issues using both knowledge systems, elder-teacher co-teaching arrangements, or place-based learning that relocates science education to community environments. These are rare but show powerful outcomes for engagement and learning (Kawagley and Barnhardt, 2005).

Studies identify factors influencing practice depth. Teacher knowledge and confidence clearly matter; integration correlates with teachers' understanding of both knowledge systems and pedagogical skills for bridge-building (Ogunniyi, 2007). Curriculum flexibility enables adaptation; rigid, overcrowded curricula constrain integration (Chikunda, 2018). Available resources including appropriate examples, lesson plans, and materials support implementation, while lack thereof creates barriers (Cronje et al.,

2015). Administrative support and professional development also enable practice (Lewthwaite et al., 2013).

2.4.4. Challenges and Tensions

Teachers attempting integration navigate multiple challenges and tensions documented in research. Epistemological tensions are frequently reported. Teachers struggle with how to present different explanations for phenomena without undermining either scientific or indigenous knowledge. They worry about creating confusion or relativism if learners conclude 'anything goes' (Cobern and Loving, 2001). Navigating topics where knowledge systems appear contradictory (e.g., supernatural versus natural causation) proves particularly challenging. Many teachers lack frameworks for productive engagement with epistemological diversity.

Practical constraints include time pressures in overcrowded curricula, making it difficult to add content or diverge from textbook sequences (Mokuku and Mokuku, 2004). Large class sizes limit discussion-based approaches needed for comparing knowledge systems. Insufficient resources, both material resources and written materials on indigenous knowledge, require teachers to create everything themselves. And examination pressures incentivize focusing on tested content, which rarely includes indigenous knowledge, making integration seem risky for learner outcomes.
Socio-cultural challenges emerge around authority and authenticity. Teachers, especially those from different cultural backgrounds than their learners, may lack confidence in their knowledge of indigenous traditions and fear misrepresenting community knowledge (Michie et al., 2018). They may be uncertain about appropriate protocols for engaging elders or using culturally sensitive knowledge. And they sometimes face resistance from parents, administrators, or even learners who view indigenous knowledge as irrelevant to modern education.

Personal identity tensions arise particularly for indigenous teachers who must navigate between their cultural identities and professional identities shaped by Western education. Some report feeling caught between worlds, uncertain whether integration honours their heritage or commodifies it for educational purposes (Stewart, 2007). These tensions reflect broader colonization impacts on indigenous peoples' relationships to their own knowledge systems.

2.4.5. Professional Development Needs

Research consistently identifies professional development as crucial for supporting integration, yet most teachers receive inadequate preparation.

Pre-service teacher education typically neglects indigenous knowledge integration entirely. Ninnes (2000) surveyed Australian teacher education programs and found indigenous knowledge absent from science methods courses. Similar findings emerge from African contexts, where teacher preparation remains firmly rooted in Western scientific frameworks (Shizha, 2014). When indigenous knowledge is addressed, it's often superficially in generic multicultural education courses rather than specifically in science methods.

In-service professional development on integration is limited and often ineffective. Teachers report that available workshops provide theoretical rationale for integration but insufficient practical strategies or resources (Cronje et al., 2015). One-shot workshops rarely create lasting change without ongoing support. And professional development often lacks community involvement, missing opportunities for teachers to learn from knowledge holders.

Effective professional development for integration likely requires several elements identified in research. They include extended duration with ongoing support rather than one-shot workshops; opportunities to develop both knowledge (of indigenous systems and pedagogy) and practical skills. Further, involvement of community knowledge holders as co-educators; collaborative structures where teachers learn from and with peers. And local adaptation to specific communities and contexts; and connection to actual curriculum and learner needs (Lewthwaite et al., 2013).

Some promising models exist. Aikenhead (2001) describes multi-year programs where Canadian teachers worked with elders, developed curriculum materials collaboratively, and supported each other's implementation. Ogunniyi (2007) reports on South African programs using action research where teachers investigated integration in their own contexts with researcher support. These models show positive outcomes but require resources and commitment often unavailable.

2.4.6. Summary and Implications

The literature on teacher knowledge and practice reveals that integration depends heavily on teachers' capacities; their knowledge, beliefs, skills, and the contexts enabling their work. Most teachers currently lack adequate preparation and support for meaningful integration, resulting in limited, superficial implementation despite policy mandates.

This study's focus on teacher narratives can contribute by documenting how teachers who do attempt integration develop necessary knowledge, navigate tensions, and create practices despite limited support. Understanding their journeys may inform more effective preparation and support for other teachers. The research also acknowledges that teachers cannot be solely responsible for integration; institutional conditions, resources, and broader societal commitments to decolonization and epistemological pluralism are equally essential.

2.5. Community Perspectives

This section reviews literature on community perspectives regarding indigenous knowledge and formal education; a domain where research remains limited but crucial for understanding integration from beyond school walls.

2.5.1. Community Views on Formal Education

Indigenous and traditional communities worldwide hold complex, often indecisive views toward formal schooling, seeing both opportunities and threats.

Many communities' value formal education as providing access to economic opportunities and broader knowledge. Serpell (2011) documents that Zambian parents consistently identify education as priority for their children, seeing it as pathway to

employment and social mobility. This reflects pragmatic recognition that economic opportunities increasingly require formal credentials and literacy skills that traditional education does not provide.

However, communities also express concerns about formal education's cultural impacts. Research across diverse contexts shows communities worry that schooling alienates children from traditional values, languages, and practices (Hornberger, 2008). Parents observe children losing interest in cultural activities, devaluing elders' knowledge, and becoming ashamed of traditional practices. This cultural distancing represents serious loss from community perspectives where cultural continuity and intergenerational connection are highly valued.

Indigenous communities specifically critique how formal education has historically suppressed their languages, knowledge systems, and cultures. Residential schools in North America and similar colonial education systems globally deliberately sought to 'civilize' indigenous children by forcing cultural assimilation (Smith, 2012). While such explicit assimilation policies have ended, communities argue that more subtle marginalization continues when curricula ignore indigenous knowledge and languages. Communities desire education that provides both modern skills and cultural grounding; what some call 'both-ways' education. Research in Australia, Canada, and New Zealand documents indigenous communities advocating for education that teaches both Western academic content and indigenous knowledge. Supporting developing bilingual and bicultural competencies rather than forcing choice between cultures (Malcolm, 2003).

In African contexts, similar patterns emerge. Communities value formal education but lament its disconnection from local realities and knowledge. Shizha (2013) reports Zimbabwean community members expressing frustration that schools teach about foreign places, organisms, and practices while ignoring local environments and indigenous knowledge. This creates a fundamental irony; education supposedly prepares youth for life in their communities yet makes community knowledge invisible.

2.5.2. Elder Perspectives on Knowledge Transmission

Community elders, recognized knowledge holders; possess unique perspectives on traditional knowledge transmission and its relationship to formal schooling. However, these perspectives are rarely documented in educational research.

Elders typically express concern about declining traditional knowledge among youth. Studies across multiple contexts show elders observing that young people know less about traditional practices, medicinal plants, ecological knowledge, and cultural protocols than previous generations (Zent, 2009). They attribute this partly to formal schooling that occupies children's time and attention previously devoted to cultural learning. When children spend days in classrooms and evenings on homework, opportunities for learning from elders diminish.

Beyond time displacement, elders note that formal education shapes how youth value knowledge. Schools implicitly or explicitly teach that book learning and scientific knowledge are superior to oral traditional knowledge. This disorients learners leading

to their dismissing of elders' knowledge as outdated, superstitious, or irrelevant (Simpson, 2004). Elders report youth showing less respect and interest in traditional learning, creating barriers to knowledge transmission even when time is available. However, elders often express openness to sharing knowledge with schools under appropriate conditions. Research finds elders generally willing to engage with education if approached respectfully, if their knowledge is valued appropriately, and if sharing serves community benefit (Aikenhead and Huntley, 1999). But they also articulate concerns and conditions.

One concern involves appropriate knowledge sharing. Some knowledge is considered sacred, proprietary to particular families or clans, gender-specific, or only appropriate for initiated individuals. Elders worry that schools might inappropriately disseminate knowledge beyond proper contexts or to people who lack necessary preparation (Simpson, 2004). This reflects fundamentally different assumptions about knowledge ownership and access than schools' open dissemination model.

Elders also express concern about decontextualization and distortion. Traditional knowledge is embedded in cultural contexts, relationships, and practices; extracting isolated facts or techniques risks misrepresentation (Nadasdy, 2003). Elders want knowledge taught holistically, including spiritual and ethical dimensions, not just instrumental applications. They worry that schools might extract what seems useful while ignoring deeper meanings.

Issues of respect and reciprocity matter deeply. Elders expect appropriate protocols when engaging with them; proper approach, explanation of purposes, compensation or gifts, ongoing relationships rather than one-time extraction. Research documents cases where elders felt used by schools or researchers who took knowledge without giving back or maintaining respectful relationships (Smith, 2012). This history creates wariness about engagement.

Some elders articulate specific visions for how schools might engage traditional knowledge. Preferences include: elders teaching directly rather than teachers translating their knowledge; teaching occurring in community settings connected to land and practice, not just classrooms; knowledge being voluntary enrichment rather than mandatory curriculum subject to evaluation; and genuine partnership where elders share authority rather than being positioned as subordinate assistants to teachers (Kawagley and Barnhardt, 2005).

2.5.3. Community Knowledge Holders Beyond Elders

While elders receive most attention, other community knowledge holders, traditional healers, farmers, craftspeople, midwives, hunters, also possess relevant perspectives rarely documented in research.

Traditional healers hold extensive botanical and medicinal knowledge highly relevant to biology education. Studies interviewing healers reveal mixed views on sharing knowledge. Some express willingness to contribute to education, seeing value in youth maintaining healing knowledge. Others express reluctance due to concerns about knowledge misuse, commercial appropriation, or losing competitive advantage if

specialized knowledge becomes widely available (Chinsembu, 2016). Nearly all emphasize that healing knowledge involves spiritual and ethical dimensions that cannot be separated from practical applications.

Traditional farmers possess sophisticated agricultural knowledge. Research engaging farmers shows pride in their expertise and desire for recognition, especially given their knowledge's proven effectiveness (Abah et al., 2015). Farmers often express frustration that agricultural extension programs and school agriculture classes ignore traditional practices, promoting instead expensive, input-intensive methods unsuitable for local conditions. They welcome opportunities to share knowledge but want genuine respect rather than tokenistic acknowledgment.

Women knowledge holders (often central to traditional medicine, food preparation, child care, and craft production) remain particularly marginalized in both research and educational engagement. The limited studies including women's perspectives show they possess extensive knowledge about nutrition, medicinal plants, child development, and ecology (Shiva, 1988). However, patriarchal structures in both traditional and formal systems often prevent women's knowledge from being recognized or shared publicly. This gendered dimension of knowledge transmission requires attention.

2.5.4. Community-School Relationships

The quality of relationships between communities and schools significantly shapes possibilities for indigenous knowledge integration. Research reveals various relationship patterns.

In many contexts, relationships are characterized by distance and mutual suspicion. Schools operate as isolated institutions with minimal community involvement beyond parent-teacher meetings focused on learner discipline or fundraising (Serpell, 2011). Teachers, especially those from different cultural or class backgrounds than learners, may have limited community knowledge or connection. Communities view schools as alien institutions imposing external values. This distance creates barriers to knowledge sharing.

Colonial legacies particularly affect community-school relationships in post-colonial contexts. Schools were historically tools of cultural suppression and assimilation, creating deep-seated community distrust that persists even when explicit policies change (Shizha, 2013). Teachers, as representatives of formal education, may be viewed with ambivalence; valued for the opportunities that education provides but also associated with cultural domination.

Some communities have developed productive partnerships with schools around indigenous knowledge. Research on successful examples identifies common features: mutual respect and recognition of both community and school knowledge; shared decision-making about what knowledge is shared and how; ongoing relationships rather than one-time interactions; reciprocity where schools contribute to communities, not just extracting knowledge; and involvement of broader community, not just selected individuals (Lewthwaite and Renaud, 2009).

However, power imbalances shape even well-intentioned partnerships. Schools ultimately control what happens in classrooms, when and how community members participate, and what knowledge is validated through assessment. Communities typically have advisory rather than authoritative roles. This structural inequality means partnerships may reinforce rather than transform colonial relationships unless actively addressed (Nadasdy, 2003).

2.5.5. Community Outcomes and Impacts

Limited research examines how indigenous knowledge integration affects communities themselves, beyond impacts on learners. The few relevant studies suggest multiple community-level outcomes.

Integration can strengthen intergenerational connections when structured to bring elders and youth together around knowledge sharing. Programs creating such opportunities show elders reporting renewed sense of value and purpose, while youth develop appreciation for elders and traditional knowledge (Bang and Medin, 2010). This contrasts with knowledge transmission erosion that occurs when schooling separates generations.

Community cultural revitalization may result when schools validate and engage indigenous knowledge. Research in language revitalization shows school-based programs can catalyze broader community language use and intergenerational transmission (McCarty and Nicholas, 2014). Similar dynamics may apply to indigenous knowledge systems; school recognition can increase community members' pride and engagement, reversing decline.

However, risks exist. Inappropriate sharing of sacred or proprietary knowledge can create community conflict if knowledge holders feel protocols were violated (Simpson, 2004). Oversimplification or distortion of knowledge can undermine rather than support knowledge systems. And token inclusion that treats indigenous knowledge as inferior may reinforce marginalization rather than challenge it.

Economic impacts may also occur. School-community partnerships can create compensation opportunities for elders who contribute, though concerns about commodifying knowledge exist (Nadasdy, 2003). Documentation of indigenous knowledge through educational materials may support intellectual property claims and benefit-sharing agreements, though it can also facilitate biopiracy if improperly managed.

2.6. Learner Experiences and Meaning-Making

This section reviews research on how learners experience and make sense of education that engages both indigenous and scientific knowledge systems. A domain where understanding remains limited despite learners being central stakeholders.

2.6.1. Cultural Identity and Science Learning

Substantial research examines relationships between cultural identity and science learning, particularly for indigenous and minority learners, providing context for understanding integration's potential effects.

Studies consistently find that science education as typically delivered creates identity conflicts for indigenous learners. When science teaching ignores or contradicts learners' cultural knowledge and when successful science performance requires adopting Western ways of thinking and being, learners face what Aikenhead (1996) calls "cultural border crossing", moving between different cultural worlds with different norms, values, and knowledge systems. For many indigenous learners, this crossing feels like choosing between cultural belonging and academic success.

Brickhouse and Potter (2001) documented how African American girls navigated tensions between family/community identities and science classroom expectations, sometimes resisting science identities to maintain cultural authenticity. Similarly, Carlone et al. (2011) showed how Latina learners experienced science as culturally foreign, creating barriers to seeing themselves as "science people." These patterns reflect what scholars call "opportunity gaps"; not deficits in learners but limitations in educational systems that fail to connect with learners' lives and identities.

Cultural identity conflicts may be particularly acute for indigenous learners given science education's colonial history. Battiste (2013) describes how Western science education has actively suppressed indigenous knowledge systems, creating deep associations between science and cultural oppression. When schools position science and indigenous knowledge as incompatible, learners from indigenous communities must choose abandonment of cultural identity to succeed in science; a choice many understandably refuse.

However, research also shows cultural identity can support science learning when education is culturally responsive. Bang and Medin (2010) found that when science connected to Native American learners' cultural knowledge and community contexts, learners showed strong engagement and developed robust science identities alongside cultural identities. This suggests identity conflicts are not inevitable but result from particular educational approaches that can be changed.

The concept of 'hybrid identities' offers useful framing. Rather than choosing between cultural and science identities, learners can develop identities integrating both, what Barton and Tan (2008) call 'being both X and scientist.' This requires educational environments that validate multiple identities and demonstrate that science and cultural belonging are compatible. Indigenous knowledge integration potentially enables such hybrid identity development.

2.6.2. Learner Engagement and Motivation

Research examining how indigenous knowledge inclusion affects learner engagement reveals generally positive patterns, though with variations.

Multiple studies document increased interest and participation when science education incorporates culturally familiar content and contexts. Boutte and Hill (2006) found African American elementary learners showed greater enthusiasm and sustained engagement when science connected to their cultural experiences versus abstract decontextualized content. Similarly, Rioux (2010) reported that Canadian indigenous

learners in culture-based science programs showed higher attendance and participation than those in conventional programs.

Several mechanisms may explain enhanced engagement. Culturally familiar content reduces cognitive load by building on existing knowledge rather than requiring complete novelty (Lee and Buxton, 2010). Seeing one's culture valued in curriculum signals belonging and mattering, increasing motivation (Nasir and Hand, 2008). Community connections make learning feel purposeful; addressing real issues rather than arbitrary academic exercises (Barton and Tan, 2010). And experiential, place-based approaches often accompanying integration may simply be more engaging than textbook-based instruction regardless of cultural content.

However, engagement effects are not universal. Some studies find no engagement differences, and occasionally report resistance from learners who view indigenous knowledge as irrelevant to their aspirations. This likely reflects variation in implementation quality, learners' relationships to indigenous cultures, and their perceptions of what knowledge is valuable for futures they envision.

Importantly, engagement alone is insufficient for learning. Learners must engage productively with intellectually substantive content. Research suggests indigenous knowledge integration supports both engagement and rigor when done well, providing culturally meaningful contexts for developing scientific understanding. But superficial inclusion that treats indigenous knowledge as entertaining diversion rather than serious intellectual content may increase engagement without supporting deep learning.

2.6.3. Conceptual Understanding and Learning Outcomes

Research on how indigenous knowledge integration affects learners' conceptual understanding of science shows complex patterns requiring careful interpretation.

Some studies document learning benefits in instructional units integrating indigenous knowledge showed stronger understanding of science concepts than those in conventional instruction. They hypothesize that culturally familiar contexts provided cognitive scaffolding, making abstract scientific principles more accessible. Similarly, Hewson and Ogunniyi (2011) found South African learners comparing indigenous and scientific explanations developed deeper understanding of both than learners exposed to science alone.

The mechanisms by which integration might support understanding include: familiar contexts reducing cognitive load and supporting meaning-making; comparison between knowledge systems developing metacognitive awareness and critical thinking; concrete cultural examples making abstract concepts tangible; and motivation from cultural relevance increasing cognitive engagement with content.

However, other studies find no achievement benefits from integration, with learners in culturally responsive and conventional programs showing similar test performance (Rodriguez, 1998). This may reflect that standardized tests, designed around Western scientific knowledge, inadequately measure understanding developed through integration. Learners may develop broader or different competences (epistemological

awareness, critical thinking, application abilities) not captured by conventional assessments.

Concerns about confusion or relativism when learners engage multiple knowledge systems appear largely unfounded. Studies specifically investigating this find learners generally capable of understanding that different knowledge systems exist and serve different purposes without concluding anything goes (Cobern and Loving, 2001). Learners develop what Ogunniyi and Hewson (2011) call 'contiguity'; capacity to hold multiple perspectives simultaneously while recognizing their different foundations and applications.

Age and developmental stage may influence learning outcomes. Some research suggests younger children navigate multiple knowledge systems more fluidly than adolescents, perhaps because they have less ingrained commitment to single correct answers (Cobern, 1996). Adolescents may need more explicit epistemological scaffolding to productively engage knowledge system comparisons.

2.6.4. Meaning-Making Processes

Understanding how learners actually make sense of education engaging multiple knowledge systems requires examining their cognitive and social processes, though research in this area remains limited.

Learners employ various strategies for navigating multiple knowledge systems. Jegede's (1995) concept of "collateral learning" describes how learners may learn scientific and indigenous knowledge simultaneously without necessarily integrating them; keeping knowledge systems separate for different contexts. Learners might use scientific knowledge for school and examinations while using indigenous knowledge for home and community life. This is not confusion but pragmatic navigation of different social worlds.

Other learners actively compare and integrate knowledge systems, seeking connections and complementarities. Ogunniyi and Hewson (2011) describe learners developing 'contiguity argumentation'; sophisticated capacity to analyze similarities and differences between explanatory frameworks, evaluate their underlying assumptions, and recognize contexts where each applies. This represents advanced epistemological thinking.

Still other learners experience genuine integration or synthesis, developing hybrid understandings that transcend either knowledge system alone. For example, understanding plant medicine might integrate chemical mechanisms (scientific) with spiritual relationships and ethical protocols (indigenous), creating richer understanding than either system offers independently. However, whether such synthesis is epistemologically coherent or desirable remains debated (Carter, 2004).

Social and dialogical processes shape meaning-making. Research emphasizes that understanding develops through conversation and interaction, not just individual cognition (Vygotsky, 1978). Classroom discussions comparing knowledge systems, conversations with elders and teachers, and peer interactions all contribute to how

learners make sense of multiple perspectives. This suggests that pedagogy fostering rich dialogue matters as much as content.

Cultural and social identities influence meaning-making. Learners strongly identifying with indigenous cultures may approach integration differently than those with weaker cultural connections. Learners from families valuing traditional knowledge may engage differently than those from families prioritizing Western education. These variations suggest that integration's meanings and effects depend on learners' particular social positions and identities.

2.6.5. Learner Perspectives on Integration

The limited research directly asking learners about their experiences of and preferences regarding indigenous knowledge integration reveals important insights.

Learners generally express positive attitudes toward indigenous knowledge inclusion. Surveys across multiple contexts show majority support for incorporating traditional knowledge in science, with learners reporting it makes learning more interesting and relevant (Mokuku and Mokuku, 2004). Indigenous learners particularly value seeing their cultures represented, reporting it increases sense of belonging and pride.

However, learners also articulate concerns and conditions. Some worry that excessive focus on traditional knowledge might disadvantage them on examinations focused on Western science (Aikenhead, 2001). Others note that superficial or tokenistic inclusion feels patronizing rather than respectful. And some learners, particularly those aspiring to urban professional careers, question traditional knowledge's relevance to their futures.

Learners identify particular integration approaches as more or less effective. They appreciate elder guest speakers who share knowledge directly; field trips and experiential learning in community settings; opportunities to interview family members about traditional practices; investigations testing traditional knowledge using scientific methods; and respectful comparisons acknowledging strengths of both knowledge systems (Lewthwaite and Renaud, 2009). They dislike being treated as representatives responsible for explaining their cultures; superficial mention without substantive engagement; and approaches suggesting indigenous knowledge is primitive or inferior. Importantly, learner perspectives vary within any group. Not all indigenous learners strongly identify with traditional knowledge or want it emphasized in school. Not all are from families maintaining traditional practices. And non-indigenous learners may also appreciate and benefit from engaging indigenous knowledge. This diversity cautions against essentialist assumptions about what learners need or want based on their cultural backgrounds.

2.7. Research Gaps

Despite growing scholarship, significant gaps remain in understanding indigenous knowledge integration in science education, particularly in African contexts. Few studies examine actual teacher narratives. Additionally, most rely on surveys or interviews about hypothetical practices. Community elder perspectives are rarely included. Research typically focuses on teachers and learners. Learner meaning-making

processes receive insufficient attention; we know little about how learners actually experience and make sense of integration. Long-term effects remain underexplored. Most studies are short-term and comparative research across different integration approaches is limited; making it difficult to assess what works best under what conditions. This study addresses several of these gaps, particularly through narrative inquiry into teacher experiences, inclusion of elder perspectives, and attention to learner meaning-making.

2.7.1. Teacher Knowledge for Integration

Integrating indigenous and scientific knowledge requires complex, multifaceted teacher knowledge beyond conventional science content knowledge. Scholars have attempted to characterize this knowledge using frameworks like pedagogical content knowledge (PCK) and its extensions. Teacher beliefs about the nature of science, indigenous knowledge, and the relationship between them significantly influence integration efforts. Research reveals diverse belief profiles.

Some teachers hold exclusivist beliefs, viewing science as universally true knowledge and indigenous knowledge as cultural belief or folklore without scientific validity. From this perspective, integration is inappropriate or impossible. Other teachers hold inclusive pluralist beliefs, recognizing indigenous and scientific knowledge as different but legitimate ways of knowing that can coexist and complement each other. These teachers view integration as both possible and valuable for various purposes. Some teachers hold what might be called assimilationist beliefs; they value indigenous knowledge but primarily as a bridge or stepping stone toward scientific understanding. Indigenous examples may be used initially but are replaced once learners grasp 'real scientific' concepts. This reflects deficit thinking that sees indigenous knowledge as inferior but pedagogically useful for culturally different learners Few teachers articulate decolonial beliefs that would position indigenous knowledge as primary and Western science as an additional perspective. This likely reflects how teachers themselves were educated in systems privileging science, combined with institutional pressures to prepare learners for examinations focused on Western scientific knowledge.

Therefore, teachers attempting integration navigate multiple challenges and tensions documented in research. Epistemological tensions are frequently reported. Teachers struggle with how to present different explanations for phenomena without undermining either scientific or indigenous knowledge. They worry about creating confusion or relativism if learners conclude anything goes. Navigating topics where knowledge systems appear contradictory (e.g., supernatural versus natural causation) proves particularly challenging. Many teachers lack frameworks for productive engagement with epistemological diversity.

2.7.2. Community Perspectives

Community elders, recognized knowledge holders; possess unique perspectives on traditional knowledge transmission and its relationship to formal schooling. However, these perspectives are rarely documented in educational research. Despite the importance of community perspectives, research in this area remains limited. Few studies centre community voices, especially in Zambian context. When included,

community members are typically asked to respond to researchers' agendas rather than articulating their own concerns and visions. Elder perspectives specifically are rarely documented, and even less research examines how elders experience and perceive school engagement with indigenous knowledge.

This study addresses these gaps by centring community elder perspectives as co-equal with teacher and learner perspectives. The research asks elders to articulate their observations, concerns, and visions regarding indigenous knowledge and formal biology education rather than only responding to researcher questions. This approach treats elders as knowledge authorities whose perspectives are essential for understanding integration, not just as sources of information about traditional practices.

2.7.3. Learner Experiences and Meaning-Making

This section reviews research on how learners experience and make sense of education that engages both indigenous and scientific knowledge systems, a domain where understanding remains limited despite learners being central stakeholders. Studies consistently find that science education as typically delivered creates identity conflicts for indigenous learners.

Understanding how learners actually make sense of education engaging multiple knowledge systems requires examining their cognitive and social processes, though research in this area remains limited. Learners generally express positive attitudes toward indigenous knowledge inclusion. However, they also articulate concerns and conditions. Some worry that excessive focus on traditional knowledge might disadvantage them on examinations focused on Western science Others note that superficial or tokenistic inclusion feels patronizing rather than respectful. And some learners, particularly those aspiring to urban professional careers, question traditional knowledge's relevance to their futures.

Despite growing recognition of learner perspectives' importance, significant research gaps remain. Most studies examine learner outcomes (test scores, attitudes) rather than meaning-making processes; how learners actually think about and make sense of multiple knowledge systems. This study addresses some gaps by examining learner experiences and meaning-making through focus group discussions that allow learners to articulate their perspectives in their own terms. While not longitudinal, the research explores how learners experience integration in the moment and what meanings they construct.

2.8. Chapter Summary

This chapter has reviewed scholarly literature relevant to understanding indigenous knowledge integration in biology education, establishing theoretical frameworks and empirical grounding for the current research.

Section 2.1 presented the integrated theoretical framework combining epistemological pluralism, cultural-historical activity theory, and post-colonial perspectives. This framework establishes that: multiple legitimate knowledge systems exist and deserve respectful engagement; teaching and learning are culturally embedded activities shaped by historical contexts and social systems; and contemporary education in post-colonial

nations continues navigating colonial legacies requiring critical attention to power and voice.

Section 2.2 examined indigenous knowledge systems themselves, revealing them as sophisticated, place-based, holistic, orally-transmitted, and dynamic knowledge systems with different epistemological foundations than Western science but employing similarly rigorous observation and reasoning within different metaphysical frameworks.

Section 2.3 reviewed science education scholarship on integration, documenting various theoretical approaches and pedagogical practices. Research shows generally positive outcomes for engagement, identity, and often learning, though implementation remains limited and faces significant challenges.

Section 2.4 analyzed teacher knowledge and practice, revealing that integration requires complex, multifaceted knowledge beyond conventional science content knowledge, including understanding of indigenous knowledge systems, awareness of epistemological differences, and skills for facilitating border crossing. Most teachers lack adequate preparation, and their beliefs about knowledge systems significantly influence practice.

Section 2.5 reviewed community perspectives, documenting complex relationships between communities and formal education characterized by both aspirations and concerns. Communities value education's opportunities but worry about cultural alienation. The elders express concerns about knowledge transmission decline and articulate conditions for appropriate school engagement with traditional knowledge.

Section 2.6 examined learner experiences and meaning-making, showing that science education can create identity conflicts for indigenous learners that integration may help resolve by enabling hybrid identities. Integration generally enhances engagement and can support conceptual understanding through various mechanisms, though effects vary with implementation quality and learner backgrounds.

Section 2.7 looked at three research gaps driving this study. The review revealed that teacher narratives of actual integration practice are scarce, community elder perspectives are almost entirely absent from the literature, and learner meaning-making processes remain poorly understood. Most research measuring outcomes rather than how learners actually think across knowledge systems. Finally, significant research gaps remain, particularly regarding actual implementation experiences, community perspectives, and learner meaning-making in African contexts. This literature review reveals that while substantial scholarship reports indigenous knowledge in science education, the specific focus of this research addresses important gaps. The theoretical framework established here guides the research design detailed in the next chapter, and will inform analysis and interpretation of findings in subsequent chapters. Chapter Three now explicates the methodological approach employed to investigate the research questions posed in Chapter One.

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III. Chapter Three - Research Methodology

3. Introduction

This chapter details the methodological approach employed to investigate how Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge in secondary biology education, and how learners make meaning when engaging with both knowledge systems. Section 3.1 articulates the research philosophy and paradigm undergirding the study, explaining the ontological, epistemological, and methodological assumptions that shaped inquiry decisions. Section 3.2 presents the overall research design and justifies this design in relation to the research questions and theoretical framework. Section 3.3 discusses the target population and sampling procedures while section 3.4 details the data collection methods employed, including semi-structured interviews, focus group discussions and survey instruments, with attention to how each method addresses specific research questions. Section 3.5 elucidates the data management while section 3.6 looks at data analysis procedures, describing both qualitative analysis techniques and quantitative analysis approaches used to make sense of the data. Section 3.7 addresses trustworthiness and credibility while acknowledging the different standards appropriate to narrative research versus conventional scientific research. Section 3.8 discusses ethical considerations and section 3.9 examines researcher positionality and reflexivity, acknowledging how the researcher's identity, background, and assumptions influenced the research. The chapter concludes with section 3.10, which synthesizes the methodological approach and connects it to the empirical work reported in Chapter Four.

3.1. Research Philosophy and Paradigm

All research operates within philosophical assumptions, often implicit, about the nature of reality, how knowledge is generated, and what methods are appropriate for inquiry. Making these assumptions explicit is essential for methodological coherence and for readers to properly interpret findings. This section articulates the philosophical paradigm guiding this research.

3.1.1. Ontological Assumptions

Ontology concerns the nature of reality, what exists and what can be known about existence. This research adopts a constructivist ontological position, which holds that reality is socially constructed through human interpretation, interaction, and meaning-making rather than existing as objective, observer-independent fact (Crotty, 1998). From this perspective, there is no single, fixed reality out there waiting to be discovered; rather, multiple realities exist as constructed by different individuals and groups based on their experiences, cultures, and social positions. Applied to this study, constructivist ontology recognizes that integration of indigenous and scientific knowledge is not an objective phenomenon with fixed characteristics but rather is constructed differently by different participants. Teachers, elders, and learners each construct meanings of integration based on their particular experiences, social locations, and cultural

frameworks. What constitutes successful integration, what challenges matter most, and what outcomes are valued all depend on who is constructing these realities.

Importantly, constructivist ontology aligns with the study's theoretical framework, particularly epistemological pluralism's recognition that multiple legitimate ways of knowing exist. Just as indigenous and scientific knowledge represent different but valid constructions of natural reality, teacher, elder, and learner perspectives represent different but valid constructions of integration as an educational phenomenon.

3.1.2. Epistemological Assumptions

Epistemology concerns the theory of knowledge, what counts as knowledge, how knowledge is generated, and the relationship between knower and known. This research adopts an interpretivist epistemological stance, which holds that knowledge is created through interpretation of human experience and meaning-making rather than through objective observation of external reality.

From an interpretivist perspective, understanding social phenomena like teaching and learning requires interpretive access to participants' subjective experiences and the meanings they construct. Knowledge is not discovered "out there" but is co-created through interaction between researchers and participants as they collaboratively make sense of experiences. The researcher cannot stand apart as objective observer but is inevitably involved in constructing knowledge through the research process.

This epistemological stance has several implications for the research. First, it prioritizes qualitative methods that allow deep exploration of meaning and experience over quantitative methods focused on measurement and generalization, though the study includes quantitative elements within an overall interpretivist framework. Second, it positions participants as knowledge authorities whose interpretations and understandings are valid sources of knowledge, not merely data to be analyzed. Third, it recognizes that the researcher's interpretations are themselves constructions influenced by the researcher's own frameworks and perspectives, requiring reflexive attention to how these shape knowledge production.

The interpretivist epistemology aligns with narrative inquiry's emphasis on understanding experience through the stories people tell and the meanings they construct. It recognizes that teachers' narratives of navigating integration, elders' perspectives on knowledge transmission, and learners' accounts of meaning-making are not merely subjective opinions but constitute legitimate knowledge about integration as a lived phenomenon. However, the study also incorporates elements of pragmatist epistemology, which evaluates knowledge claims based on their practical usefulness and consequences rather than correspondence to external reality (Creswell and Plano Clark, 2018). The inclusion of quantitative survey data reflects pragmatist recognition that different types of knowledge serve different purposes, narrative depth and statistical breadth both contribute useful but different insights. Pragmatism provides philosophical justification for mixed-methods research that would be difficult within pure interpretivism.

3.1.3. Alignment with Theoretical Framework

The research philosophy and paradigm align closely with the theoretical framework presented in Chapter Two. The constructivist ontology harmonizes with epistemological pluralism's recognition that multiple legitimate constructions of reality exist, both across cultures (indigenous versus scientific worldviews) and across individuals (different participants' constructions of integration). Interpretivist epistemology aligns with the theoretical emphasis on understanding how teachers, elders, and learners make meaning of their experiences navigating between knowledge systems. The narrative inquiry methodology particularly aligns with post-colonial theory's emphasis on centring marginalized voices and challenging Western research dominance. By prioritizing participants' stories told in their own words, narrative inquiry resists extractive research approaches that reduce participants to data sources. Instead, it positions them as knowledge authorities whose narratives constitute the research findings themselves, not merely raw material for researcher analysis.

Cultural-historical activity theory also aligns with the interpretivist paradigm's attention to context, culture, and meaning. CHAT directs attention to the cultural tools, historical contexts, and activity structures shaping teaching and learning, dimensions best understood through interpretive methods that explore how participants experience and navigate these contexts rather than seeking to measure them objectively.

3.2. Research Design

This section presents the overall research design, the strategic framework organizing data collection and analysis to address the research questions. The design is characterized as descriptive and exploratory mixed-methods research anchored in narrative inquiry.

3.2.1. Descriptive and Exploratory Nature

The research is fundamentally descriptive and exploratory rather than explanatory or experimental. Descriptive research seeks to document and characterize phenomena as they exist, while exploratory research investigates areas where little is currently known, generating insights and questions rather than testing predetermined hypotheses. The research describes the lived reality of integration in specific contexts as constructed by participants, without imposing predetermined categories or hypotheses about what should be found.

3.2.2. Mixed-Methods Design

The study employs a mixed-methods design, collecting and analyzing both qualitative and quantitative data. Specifically, it uses an explanatory sequential mixed-methods approach with qualitative priority. The qualitative component includes in-depth semi-structured interviews with biology teachers, community elders and focus group discussions with learners. These methods generate rich narrative and thematic data about experiences, perspectives, and meanings constructed by participants. The quantitative component consists of a survey distributed to a broader sample of biology teachers.

The integration of qualitative and quantitative data occurs primarily at the interpretation stage rather than through merged databases or joint displays during analysis. After

analyzing qualitative and quantitative data separately using appropriate techniques for each, the findings are brought together in Chapter Four's integrated analysis section and in Chapter Five's discussion to show how they complement each other. However, the design maintains clear priority for qualitative inquiry. The quantitative survey is explicitly positioned as supplementary to the primary narrative inquiry rather than co-equal. This priority reflects the study's interpretivist paradigm, which views rich understanding of meaning and experience as more valuable for addressing the research questions than statistical patterns. The survey serves to contextualize narratives, not to validate them through numerical corroboration.

3.2.3. Narrative Inquiry Framework

Within the overall mixed-methods design, narrative inquiry provides the methodological framework for the qualitative component. Narrative inquiry, as developed by Clandinin and Connelly (2000), treats human experience as fundamentally narrative in structure and meaning. People understand their lives through stories that connect events across time, creating coherence and meaning from experience. To understand how teachers navigate integration, how elders perceive schools' engagement with indigenous knowledge, and how learners make sense of encountering multiple knowledge systems, the research must access and analyze the stories they tell.

Applied to this study, temporality involves understanding teachers' narratives as journeys, how they came to attempt integration, how their practices evolved, how they experienced particular moments of tension or success. It involves understanding elders' narratives about changes in knowledge transmission over time and their evolving perspectives on formal education. And it involves understanding learners' experiences of engaging with both knowledge systems as unfolding processes of meaning-making rather than static states.

Narrative inquiry involves several distinctive features that shape this study's approach. First, it emphasizes collaborative relationship between researcher and participants in constructing research texts. Rather than treating participants as subjects providing data for researcher analysis, narrative inquiry positions researcher and participants as co-constructors of narrative accounts. This collaborative orientation aligns with the study's post-colonial commitments to respectful, non-extractive research.

Second, narrative inquiry attends to narrative coherence and resonance rather than conventional validity criteria. The quality of narrative accounts is evaluated based on whether they ring true to experience, whether they provide useful insights, and whether they resonate with readers' own experiences, what Clandinin and Connelly (2000) call 'verisimilitude' and 'authenticity' rather than correspondence to external reality.

3.2.4. Design Rationale and Research Questions Alignment

The overall research design, descriptive-exploratory mixed-methods anchored in narrative inquiry, aligns well with the study's research questions and purposes.
The main research question asks how teachers and elders navigate integration and how learners make meaning when engaging with both knowledge systems. The word 'how' signals that the question seeks understanding of processes, experiences, and practices

rather than measurement of outcomes or testing of relationships. Narrative inquiry, with its focus on understanding experience through stories, is particularly well-suited to answering 'how' questions about human experience and meaning-making.

The subsidiary questions similarly call for methods that allow deep exploration of lived experience. Questions about teachers' pedagogical strategies, epistemological tensions, and factors supporting or constraining practice require rich qualitative data showing how teachers actually navigate these dimensions in context. Questions about elders' observations, concerns, and visions for community-school relationships require methods that centre elder voices and perspectives. Questions about learner navigation of apparent contradictions and effects on identity and belonging require access to learners' own meaning-making processes.

3.3. Target Population and Sampling

This section describes the target populations for the study and explains the sampling strategies and procedures used to select participants from those populations. Different sampling approaches were used for different participant groups, reflecting their different roles in the research and the different purposes they serve.

3.3.1. Target Populations

The study involved three distinct target populations:

3.3.1.1. Biology Teachers

All secondary school biology teachers in Zambia constitute the broad target population, though the accessible population was limited to teachers in selected provinces and districts. The specific target population for narrative inquiry included biology teachers currently teaching at Forms 1-2 and Grades 10-12 levels who have some experience with or expressed interest in integrating indigenous knowledge with scientific content, or who have reflected on why they do not attempt such integration. For the quantitative survey, the target population was more broadly defined as biology teachers in the research provinces regardless of their integration experience or attitudes.

3.3.1.2. Community Elders

The target population included recognized knowledge holders in communities surrounding selected schools; individuals acknowledged within their communities as possessing traditional knowledge related to ecology, medicinal plants, agriculture, and natural resource management, and who play or have played roles in transmitting this knowledge to younger generations. This population is not easily quantifiable, as 'elder' is a social role rather than a demographic category, and recognition as a knowledge holder is culturally defined rather than formally credentialed.

3.3.1.3. Secondary School Learners

The target population included learners in Forms 1-2 and Grades 10-12 who are currently studying biology or have recently completed biology coursework. This age range (typically 14-19 years) represents learners with sufficient biology education to reflect on the topic while still being actively engaged in secondary schooling. Learners who have experienced some form of integration in their biology education were particularly relevant, though learners in conventional biology classes without integration also provided useful perspectives.

3.3.2. Sampling Strategy and Procedures

Given the different purposes of different research components, multiple sampling strategies were employed:

a) Purposive Sampling for Teacher Narratives

For the in-depth interviews central to narrative inquiry, purposive sampling was used to select teachers whose experiences would be particularly informative. Maxwell (2013) describes purposive sampling as deliberately selecting participants based on their potential to provide rich information relevant to research questions rather than aiming for statistical representativeness.

The selection criteria for teacher narrative participants included: (1) currently teaching biology at secondary level, (2) having attempted to integrate indigenous and scientific knowledge in their teaching, or having consciously decided not to do so, (3) willingness and ability to articulate and reflect on their experiences, (4) diversity in cultural backgrounds, teaching contexts (urban/rural), and years of teaching experience, and (5) recommended by colleagues, administrators, or provincial education officials as thoughtful practitioners.

Twelve teachers were purposively selected, two from each of the six provinces. This distribution reflects both the relative size of teacher populations in these provinces and the desire to ensure adequate representation from rural contexts where indigenous knowledge may be more actively practiced. Initial identification of potential teacher participants occurred through consultation with provincial resource centre coordinators who suggested teachers known for innovative practices or strong reflective capacities. The researcher then explained the research, and assess their willingness and appropriateness for the study. Teachers who expressed genuine interest and demonstrated capacity for thoughtful reflection on their practice were invited to participate.

b) Purposive Sampling for Community Elders

Community elders were also sampled purposively, though the process differed given the different community context. The researcher worked with educational leaders in communities surrounding schools to identify individuals recognized as knowledge holders regarding traditional ecological knowledge, medicinal plants, and agricultural practices.

Selection criteria included: (1) recognized within their community as possessing traditional knowledge relevant to biology, (2) having experience transmitting knowledge to younger generations (as traditional healers, farmers, or community educators), (3) willingness to discuss their perspectives on formal education and indigenous knowledge, (4) ability to communicate in either English or a language the researcher could access with translation assistance, and (5) diversity in gender and specific knowledge domains.

Six elders participated, one from each province. This distribution reflects the desire to include the community in the study. Among the six, three were male and three were female, reflecting the gender balance dynamics. Ages ranged from 50 to 78 years.

The identification process involved multiple steps. First, educational leaders suggested potential participants. The researcher then contacted the suggested individuals, explained the research through local liaison persons who had community trust, and invited participation. Several initially suggested individuals declined due to concerns about sharing sacred knowledge or skepticism about whether the research would benefit their communities. Those who agreed to participate did so after assurances about ethical protections.

c) Purposive Sampling for Focus Groups

Learner participants for focus group discussions were selected through purposive sampling within selected schools. The researcher worked with biology teachers to identify learners who met the following criteria: (1) currently studying or recently completed biology, (2) representing diversity in gender, (3) having experienced some form of integration in their biology education, or able to reflect on its absence, (4) articulate and willing to discuss their learning experiences.

Seven focus groups were conducted, each with 12 participants (total 84 learner participants). Focus groups were distributed across research sites. Within the criterion of diversity, the researcher intentionally included learners with varying levels of connection to indigenous knowledge in their home lives. Some participants came from families actively practicing traditional agriculture or using traditional medicine, while others had minimal exposure to indigenous knowledge outside school. This diversity allowed exploring how integration experiences vary based on learners' prior knowledge and cultural connections.

d) Random Sampling for Teacher Survey

For the quantitative survey component, a different sampling approach was used to achieve broader representation. The target population was all secondary biology teachers in the six research provinces. Using the Ministry of Education database and the provincial offices, the researcher obtained lists of target teachers.

From these lists, stratified random sampling was employed. Schools were stratified by province Within each stratum, schools were randomly selected, and all biology teachers in selected schools were invited to complete the survey. This approach ensured proportional representation across provinces and location types while maintaining random selection within strata.

The survey was distributed to 53 teachers, of whom 50 completed and submitted electronic forms (94.3% response rate). This sample size provides adequate statistical power for descriptive analysis and for detecting moderate-to-large correlations between variables. The sample characteristics broadly match the known demographics of Zambian secondary biology teachers regarding gender, experience, and location, suggesting reasonable representativeness, though some sampling bias likely exists favouring teachers more accessible and responsive to research requests.

3.3.3. Sample Characteristics

a) Teacher Interview Participants (n=12)

The twelve teachers participating in narrative interviews included six males and six females, with teaching experience ranging from 15 to 28 years (mean = 18.9 years). Seven teachers held bachelor's degrees in science education, four held diplomas in secondary education, and one held a master's degree in biology education. Nine teachers were teaching in their own ethnic communities where they had cultural knowledge relevant to integration, while three were teaching in communities different from their own cultural backgrounds. Five teachers taught in government schools, four in grant-aided schools, and three in private schools.

b) Community Elder Participants (n=8)
The eight elders included three males and five females, aged 54-78 years (mean = 66 years). Two were recognized traditional herbalists with extensive knowledge of medicinal plants, three were experienced farmers with specialized knowledge of traditional agriculture and crop varieties, and three was a former traditional leader with broad ecological knowledge. All had actively transmitted knowledge to younger generations through apprenticeship or community teaching, though several expressed that such transmission opportunities are declining. Educational levels varied, one had never attended formal school, two completed secondary education, three completed were civil servants, reflecting the diverse education access the sample.

c) Focus Group Participants (n=126)
The 126 learners, with varied academic performance levels and wide cultural backgrounds, provided diverse perspectives.

d) Survey Respondents (n=55)
The 55 surveyed biology teachers demonstrated considerable professional experience. Teaching experience ranged from 2 to 28 years, with a mean of approximately 10.6 years. The majority (roughly 60%) had taught for 10 or more years, indicating a predominantly experienced sample. Most teachers taught senior secondary biology (Grades 10-12 and Forms 1-2), with several also having primary school backgrounds. A small proportion (approximately 15%) reported fewer than 5 years of experience, representing early-career teachers. Collectively, the sample reflected a broad cross-section of experience levels across both government and private school settings in urban, peri-urban, and rural areas of Zambia. This distribution roughly matches the teacher population distribution in the research provinces.

3.3.4. Sample Size Justification

The sample sizes for different research components reflect different purposes and methodological traditions.

For narrative inquiry, the twelve teacher interviews align with recommendations that narrative research prioritizes depth over breadth, typically involving small numbers of participants (5-20) whose stories are explored extensively (Clandinin and Connelly, 2000). Twelve allows adequate diversity in experiences and contexts while remaining manageable for the intensive analysis narrative inquiry requires. The eight elder interviews similarly provide sufficient diversity while allowing deep engagement with each elder's perspectives.

The nine focus groups with maximum 13 participants each follows focus group research recommendations that 4-8 groups provide adequate data for thematic saturation while 6-10 participants per group allow all voices to be heard without groups becoming unwieldy (Krueger and Casey, 2015). The total of 126 learners provides diverse perspectives while remaining analytically manageable.

The survey sample of 55 teachers provided adequate statistical power for the descriptive purposes it serves. With this sample size, percentages can be estimated with margins of error around ±9% at 95% confidence level, and moderate correlations ($r > 0.25$) can be detected with adequate power. While larger samples would improve precision, the survey's purpose is to contextualize narratives rather than make precise population estimates, making 189 adequate.

3.4. Data Collection Methods

This section details the specific methods used to collect data, including instruments, procedures, and considerations for each method. Three primary data collection methods were employed: semi-structured interviews, focus group discussions and a questionnaire survey.

3.4.1. Semi-Structured Interviews

In-depth, semi-structured interviews served as the primary data collection method for narrative inquiry with teachers and community elders. Semi-structured interviews used an interview guide with predetermined open-ended questions but allow flexibility to follow interesting leads, ask follow-up questions, and adapt to each participant's responses (Rubin and Rubin, 2012). Separate interview guides were developed for teachers and elders, though both were structured around the research questions and narrative inquiry's three-dimensional space of temporality, sociality and place. The teacher interview guide included sections exploring: biographical background and teaching journey; understanding of indigenous knowledge and its relationship to biology; experiences attempting or not attempting integration, including specific examples and stories; pedagogical strategies and approaches used; epistemological tensions encountered and how they were navigated; institutional and community contexts affecting practice; outcomes observed; and reflections on future possibilities and needed supports.

The elder interview guide included sections exploring: the elder's background and knowledge domains; traditional knowledge transmission practices and changes observed over time; perspectives on formal schooling generally; observations about how schools engage or ignore indigenous knowledge; concerns, hopes, and visions regarding indigenous knowledge in education; views on appropriate roles for elders in education; and specific examples of knowledge they believe should or should not be included in schools. Both guides were piloted with two teachers and two elders not included in the final sample. Pilot participants provided feedback on question clarity, appropriateness, and whether the interview flowed naturally. Based on pilot feedback, some questions were reworded for clarity, the sequence was adjusted for better flow, and several probes were added to help participants elaborate their responses.

3.4.1.1. Interview Procedures

Teacher interviews occurred primarily in schools during teachers' free periods or after school and via calls, at times and locations convenient for participants. Each interview lasted 20-30 minutes and was conducted in English, the language of instruction in Zambian schools and one all teachers were comfortable using.

Elder interviews occurred in community settings chosen by elders; typically, their homes or under community meeting places and over phones. A research assistant from the local community who spoke the local language accompanied the researcher to facilitate appropriate cultural protocols and provide translation when needed, though several elders chose to conduct interviews in English or in a language the researcher spoke. Interviews lasted 30-45 minutes depending on how much elders wished to share.

3.4.1.2. Data Recording

All interviews were audio recorded with permission using a digital recorder, with backup recording on a smartphone. Detailed field notes were taken during and immediately after interviews, documenting observations about setting, participant demeanour, non-verbal communication, and researcher reflections. For elder interviews where translation occurred, both the original language and English translation were recorded when possible.

3.4.2. Focus Group Discussions

Focus group discussions with learners provided data on learner experiences and meaning-making. Focus groups involved facilitated discussion among 6-12 participants, allowing exploration of shared experiences while also revealing diversity in perspectives (Krueger and Casey, 2015).

3.4.2.1. Focus Group Guide Development

The focus group discussion guide was structured around learner experiences of biology education, engagement with both indigenous and scientific knowledge, and meaning-making processes when encountering both systems.

The guide included warm-up activities to help learners relax, followed by discussion prompts. Discussion prompts were phrased accessibly for adolescents, using concrete examples and scenarios. Visual aids including photos of local plants and animals, traditional practices, and science laboratory work were used to stimulate discussion. The guide was piloted with a focus group of learners at a school not included in the final sample, leading to simplification of some prompts and addition of more engaging activities.

3.4.2.2. Focus Group Procedures

Each focus group was conducted in a comfortable setting at the school (usually a library or empty classroom) arranged with chairs in a circle to encourage interaction. Sessions lasted 20-30 minutes and were conducted in English, though learners were encouraged to use local language terms when helpful and to mix English with local languages as they naturally would.

The researcher served as facilitator, with a research assistant taking detailed notes and helping manage logistics. Ground rules were established at the beginning emphasizing all perspectives are valuable. Ice-breaker activities helped participants relax and begin talking.

The research assistants (teachers) encouraged broad participation, gently drawing out quieter learners while managing more dominant voices. When discussions became particularly animated about specific topics, these were allowed to unfold organically rather than rigidly following the guide.

3.4.3. Questionnaire Survey

A self-administered questionnaire survey collected data from a broader sample of biology teachers, providing quantitative data to contextualize the qualitative narratives.

3.4.3.1. Survey Instrument Development

The survey instrument included both closed-ended and limited open-ended questions organized into sections: demographic information (gender, age, education level, teaching experience, school location); knowledge and beliefs about indigenous knowledge and its relationship to science; attitudes toward integration; self-reported integration practices; perceived barriers and supports for integration; and professional development experiences and needs.

Many items were adapted from existing instruments used in similar research (Abonyi et al., 2014, modified for the Zambian context. The survey included several open-ended questions allowing teachers to elaborate on their experiences. The instrument was piloted with 15 teachers from schools not in the final sample. Based on pilot feedback, some question wording was clarified, redundant items were removed, and the layout was improved for better visual flow. Pilot data were also used to assess internal consistency of Likert scale items, with acceptable Cronbach's alpha values ($\alpha > 0.70$) for attitude and practice scales.

3.4.3.2. Survey Procedures

The survey was distributed in electronic formats. Teachers completed surveys immediately or returned them within one week. For teachers in schools the researcher could not visit personally, electronic versions using an online survey platform were sent to teachers with email addresses and WhatsApp, with multiple reminders to encourage completion.

Participation was voluntary and anonymous. Surveys included no identifying information beyond general demographics. The cover letter emphasized that participation or non-participation would not affect teachers in any way and that data would be reported only in aggregate.

3.4.4. Document Review

As a supplementary data source, relevant documents were collected and reviewed, including curriculum documents, textbooks, policy statements, and integration resources whenever available. These documents provided context for understanding the formal curriculum expectations and available resources. Document review involved

reading documents critically, noting explicit and implicit messages about indigenous knowledge, identifying gaps between policy rhetoric and curriculum reality, and using documents to triangulate data from other sources. While document analysis was not a primary method, it provided important contextual information referenced in findings.

3.5. Data Management and Organization

All data were carefully managed to ensure security, organization, and accessibility for analysis. Audio recordings were transferred from recorders to password-protected computer immediately after collection, with backups on external hard drive stored separately. Field notes and observation notes were typed and organized by participant and date. Survey responses were automatically captured by learning management platform; a Ministry of Education data management system created and developed by the Directorate of National Science Centre.

All data files used only pseudonyms. Digital files were organized in clearly labelled folders by data type and site. Regular backups ensured no data loss. This careful data management facilitated efficient analysis while protecting participant confidentiality and ensuring data integrity.

3.6. Data Analysis Procedures

This section describes the procedures used to analyze the diverse data collected through the methods described above. Different analytical approaches were used for qualitative and quantitative data, reflecting their different natures and purposes.

3.6.1. Qualitative Data Analysis: Overview

The qualitative data, interview transcripts, focus group transcripts, observation field notes, and open-ended survey responses, were analyzed using a combination of narrative analysis and thematic analysis techniques. These complementary approaches allowed both preserving the narrative integrity of participants' stories and identifying themes across cases.

All analysis was iterative and recursive rather than strictly linear. The researcher moved back and forth between data and emerging interpretations, between individual cases and cross-case patterns, and between inductive and deductive coding. This iterative process is characteristic of qualitative analysis and essential for developing well-grounded interpretations (Miles et al., 2014).

3.6.2. Transcription and Initial Familiarization

Analysis began with transcription of audio recordings. All interviews and focus groups were transcribed verbatim in the language spoken, with translations provided for portions in local languages. Transcription was done by the researcher for about half of the interviews, allowing deep immersion in the data, while a hired transcriber (computer expert) completed the remainder under strict confidentiality agreements. The researcher checked all transcripts against audio recordings for accuracy. Transcripts followed conventions marking pauses, laughter, emphasis, and interruptions, as these features contribute to narrative meaning. However, extremely detailed linguistic features (e.g., length of pauses in seconds) were not marked, as the analysis focused on content and narrative structure rather than linguistic microanalysis.

During and after transcription, the researcher engaged in initial familiarization, reading each transcript multiple times while listening to recordings to capture tone and emotion. Initial impressions, questions, and potential themes were noted in analytic memos. This familiarization process generated preliminary premonitions about patterns and meanings that guided subsequent coding.

3.6.3. Narrative Analysis

Narrative analysis, following Clandinin and Connelly's (2000) approach, was applied to individual interview transcripts to develop narrative accounts of each participant's experience. This involved several steps:

a) Identifying Narrative Segments

The first step involved identifying narrative segments within interview transcripts; extended passages where participants told stories about particular experiences or events. These were distinguished from more general statements or abstract reflections. For example, a teacher describing a specific lesson where an elder visited versus making general statements about the value of indigenous knowledge.

b) Analyzing Narrative Structure

For each narrative segment, the researcher analyzed structure, attending to: plot (sequence of events and how they were connected), characters (who was involved and how they were portrayed), setting (where and when events occurred), conflict or tension (problems or challenges faced), and resolution (how situations were resolved or left unresolved). This structural analysis revealed how participants constructed meaning through narrative form.

c) Three-Dimensional Space Analysis

Each narrative was analyzed using Clandinin and Connelly's three-dimensional space:

- Temporality

How did events unfold over time? What past experiences shaped present situations? What futures were envisioned or hoped for?

- Sociality

What social and personal conditions shaped experiences? What cultural norms, institutional contexts, or relationships were relevant? What emotions, hopes, or aesthetic responses were expressed?

- Place

Where did experiences occur? How did particular places (schools, communities, landscapes) matter to experiences and meanings?

This three-dimensional analysis ensured attention to the contextual, relational, and temporal complexity of participants lived experiences.

d) Constructing Narrative Accounts

Based on this analysis, narrative accounts were constructed for each participant; coherent stories synthesizing their interview content while preserving narrative voice and structure. These accounts were not merely summaries but re-presentations that

maintained the experiential and temporal flow of participants' narratives. Following narrative inquiry's collaborative principles, draft narrative accounts were shared with participants for their feedback and revision. Some participants requested changes to ensure accuracy or appropriate representation, which were incorporated. This collaborative construction recognized participants as authorities on their own experiences.

3.6.4. Thematic Analysis

While narrative analysis preserved individual stories, thematic analysis identified patterns across participants. Thematic analysis, as described by Braun and Clarke (2006), involves identifying, analyzing, and reporting patterns (themes) within data. This study used both inductive (data-driven) and deductive (theory-driven) thematic analysis.

a) Initial Coding

After familiarization and narrative analysis, systematic coding began. Using NVivo qualitative analysis software, the researcher coded all interview and focus group transcripts line-by-line, assigning codes representing content of each passage. Some codes were inductive, emerging directly from data (e.g., "using proverbs to explain concepts"), while others were deductive, based on theoretical framework and research questions (e.g., "epistemological tension").

The researcher maintained a coding journal documenting decisions about code definitions, when codes were added or merged, and interpretive questions. This created audit trail supporting trustworthiness. Initial coding generated approximately 150 codes across all transcripts.

b) Searching for Themes

After coding all data, codes were collated and examined for patterns. The researcher created visual maps grouping related codes into potential themes. Some codes formed clear theme clusters, while others were outliers requiring further analysis. Potential themes were defined and refined through iterative consideration of whether they captured coherent patterns and were supported by sufficient data.

c) Reviewing and Defining Themes

Potential themes were reviewed by: (1) re-reading all data excerpts for each theme to ensure coherent fit, (2) reviewing entire dataset to confirm themes captured important patterns, and (3) considering whether themes answered research questions and told a coherent overall story. Some potential themes were combined, others split, and some renamed for clarity. Final themes were precisely defined, specifying what each theme was and wasn't, its essence, and boundaries. These definitions guided data organization in Chapter Four.

The thematic analysis identified themes within each participant group (teachers, elders, learners) and across groups where relevant. Within-group themes captured experiences specific to each stakeholder, while cross-cutting themes revealed patterns spanning multiple perspectives.

d) Integration of Narrative and Thematic Analysis

The narrative accounts of individual participants and the thematic analysis across participants were integrated in Chapter Four. Individual narratives illustrated themes with concrete stories, while themes provided analytical framework organizing multiple narratives. This integration maintained both the particular (individual stories) and the general (cross-case patterns).

3.6.5. Quantitative Data Analysis

Survey data received quantitative analysis using SPSS statistical software, though the analytical approach remained primarily descriptive rather than inferential, reflecting the survey's purpose of contextualizing rather than testing hypotheses.

a) Data Cleaning and Preparation

After survey data entry or export, data were cleaned by checking for missing values, out-of-range responses, and data entry errors. Missing data were minimal (<3% for most items) and handled through listwise deletion for relevant analyses. Reverse-coded items were recoded so that higher scores consistently indicated more positive attitudes or more frequent practices.

b) Scale Construction

Several Likert items measuring related constructs (attitudes toward integration, perceptions of barriers) were combined into scales after confirming internal consistency (Cronbach's alpha > 0.70). Scale scores were computed as means of constituent items.

c) Descriptive Statistics

For all survey variables, descriptive statistics were calculated: frequencies and percentages for categorical variables (gender, location type, school type), means and standard deviations for continuous variables (years of experience, attitude scales, practice frequency). These descriptives characterized the sample and the distribution of key variables.

d) Analysis of Open-Ended Survey Responses

Brief open-ended survey responses were analyzed thematically using similar procedures as interview data, though less extensively. Responses were coded to identify common themes in teachers' reported barriers, supports, and suggestions. These themes supplemented quantitative findings by providing explanatory depth.

3.6.6. Integration of Qualitative and Quantitative Findings

As noted in section 3.2, this study uses mixed methods with qualitative priority. Integration of findings occurred primarily at the interpretation stage, after separate analysis of qualitative and quantitative data.

Integration involved several processes:

a) Contextualization

Survey findings provided context for interpreting narrative accounts, showing how representative narrative participants' experiences were of broader teacher population

b) Elaboration
Narrative accounts elaborated and explained patterns observed in survey data, showing why certain attitudes or practices were common or rare

c) Triangulation
Convergence between survey and qualitative findings strengthened confidence in conclusions, while divergence signalled need for further interpretation

d) Complementarity
Different methods illuminated different aspects; surveys showed "what" patterns existed across samples, while narratives showed "how" and "why" particular experiences unfolded

This integration is presented in Chapter Four's integrated analysis section and in Chapter Five's discussion, where findings from all data sources are synthesized to address research questions comprehensively.

3.6.7. Use of Analytical Software

Qualitative analysis was supported by Learning Management Platform software, which facilitated organizing, coding, and retrieving data. However, the software was used as tool supporting researcher thinking rather than automating analysis. All coding decisions, theme development, and interpretations were made by the researcher; Learning Management Platform simply made managing large amounts of textual data more efficient.

Quantitative analysis used excel for statistical calculations and graphics. Again, software facilitated calculation but did not replace researcher interpretation of results' meanings.

3.7. Trustworthiness and Credibility

Ensuring quality and rigor in qualitative research requires attention to criteria appropriate to interpretivist paradigms rather than simply applying positivist validity and reliability standards. This section describes strategies employed to establish trustworthiness and credibility following Lincoln and Guba's (1985) framework and Clandinin and Connelly's (2000) narrative inquiry criteria.

3.7.1. Credibility

Several strategies enhanced credibility:

a) Prolonged Engagement
Rather than brief data collection encounters, the researcher spent five months in the field, conducting multiple interviews with some participants, and maintaining ongoing contact. This prolonged engagement-built trust, allowed deeper understanding of contexts, and enabled following up on emerging themes.

b) Triangulation
Multiple forms of triangulation strengthened credibility.

- Method triangulation

Using interviews, focus groups, and surveys allowed comparing findings across methods

- Source triangulation

Gathering data from teachers, elders, and learners provided multiple perspectives on integration

- Theory triangulation

Interpreting findings through multiple theoretical lenses (epistemological pluralism, CHAT, post-colonial theory) provided richer understanding than single theoretical frame

- Investigator triangulation

While the researcher conducted most data collection and analysis, key interpretations were discussed with thesis supervisors and with peer researchers in a qualitative research group, providing additional perspectives

c) Member Checking

Draft narrative accounts and preliminary findings were shared with participants to verify accuracy and appropriateness of representation. Most participants confirmed accounts as accurate, though some requested minor modifications for clarity or privacy. A few participants added additional reflections after reading drafts, which were incorporated. This collaborative verification enhanced confidence that findings represented participants' perspectives rather than solely researcher constructions.

d) Peer Debriefing

Throughout data collection and analysis, the researcher engaged in peer debriefing with thesis supervisors, colleagues, and a qualitative research group. These sessions involved presenting emerging findings, discussing interpretive decisions, and receiving critical feedback. Peers asked probing questions that pushed deeper analysis and challenged assumptions, strengthening interpretations.

3.7.2. Transferability

Transferability concerns whether findings might apply to other contexts. While qualitative research doesn't claim statistical generalizability, it can provide sufficient detail for readers to assess potential transferability to their contexts. This study enhances transferability through:

a) Thick Description

Findings in Chapter Four include thick description (Geertz, 1973) of contexts, participants, and experiences with sufficient detail that readers can understand the particularities and judge whether findings might transfer to their contexts. Rather than thin descriptions that strip away context, thick description preserves the rich complexity of situations.

b) Diverse Sampling

Purposive sampling ensured diversity in contexts (urban/rural, different provinces, different cultural groups), participant characteristics (gender, experience, school types), and experiences (teachers attempting and not attempting integration). This diversity increases likelihood that findings capture broader range of possibilities rather than only one narrow context.

c) Narrative Particularity and Resonance

Narrative inquiry prioritizes particularity, detailed understanding of specific individuals' experiences, over generalization. However, particular narratives can resonate with readers' own experiences, creating what Stake (1995) calls 'naturalistic generalization' based on recognition and experiential connection. The narrative accounts in Chapter Four aim for such resonance.

3.7.3. Dependability

Dependability concerns whether research processes were systematic and well-documented enough that findings are dependable despite the inevitable influence of researcher and context. Strategies included. Throughout the research, detailed records documented decisions and procedures.

a) Research journal tracking methodological decisions and rationales
b) Coding journal documenting coding decisions, code definitions, and changes
c) Analytical memos recording emerging interpretations and questions
d) Clear data management system with all data organized and accessible

This audit trail allows external review of research procedures and interpretive decisions, enhancing confidence in findings' dependability.

3.7.4. Confirmability

Confirmability concerns whether findings are grounded in data rather than solely in researcher biases and assumptions. Strategies included:

a) Reflexivity

Ongoing reflexive attention to how researcher identity, assumptions, and biases shaped inquiry helps ensure findings represent participants' perspectives rather than simply confirming researcher expectations.

b) Data Grounding

All findings reported in Chapter Four are extensively grounded in data, with multiple quotations and examples provided. This allows readers to assess whether interpretations are supported by evidence.

c) Negative Case Analysis

During analysis, the researcher actively searched for negative cases; instances that didn't fit emerging patterns or themes. These negative cases were examined to determine whether themes needed revision or whether they represented genuine exceptions. Several negative cases appear in Chapter Four, acknowledging complexity and variation rather than presenting overly neat patterns.

d) Alternative Explanations

For key findings, the researcher considered alternative interpretations, discussing these in analytical memos and with supervisors. When alternative explanations seemed viable, these are acknowledged in findings presentation.

3.7.5. Authenticity

a) Fairness

The inclusion of teacher, elder, and learner perspectives ensures multiple stakeholder voices are heard rather than privileging one group. Within teacher group, both those attempting and not attempting integration were included.

b) Ontological Authenticity

Several participants reported that the interview process helped them clarify their own thinking and prompted deeper reflection about integration. This suggests ontological authenticity, though this was not systematically assessed.

3.8. Ethical Considerations

3.8.1. Ethical Principles

The research was guided by four fundamental ethical principles; respect for Persons, beneficence, justice and cultural respect.

Recognizing participants' autonomy and right to make informed decisions about participation. This included providing complete information about the research, ensuring voluntary participation free from coercion, and respecting participants' decisions to participate, decline, or withdraw. Maximizing potential benefits while minimizing potential harms. Benefits included opportunities for reflection, contribution to knowledge about important educational issues, and potential influence on policy and practice. Potential harms, primarily time burden and possible distress from discussing sensitive topics, were minimized through careful procedures. Ensuring fair distribution of research burdens and benefits. Participant selection was based on relevance to research questions rather than convenience or vulnerability. Benefits of the research (new knowledge, potential improvements to education) should ultimately benefit participants' communities rather than only benefiting the researcher or academic institutions. Distinguishing and honouring cultural protocols, knowledge systems, and values of participating communities. This involved approaching elders respectfully through appropriate channels, following cultural protocols for interaction, and treating indigenous knowledge with the seriousness and respect it deserves rather than as mere research material.

3.8.2. Confidentiality and Anonymity

Strict confidentiality and anonymity protections were implemented:

a) Data Anonymization

All data were anonymized immediately upon collection. Participants were assigned pseudonyms used in all transcripts, field notes, and research outputs. Any identifying details in data (specific school names, villages, recognizable personal information) were changed or removed to prevent identification.

b) Secure Data Storage

All data were stored securely. Digital files were kept on password-protected computers with encrypted backups. Physical materials (consent forms, field notes) were locked in filing cabinets accessible only to the researcher. The master list linking pseudonyms to real identities was stored separately in locked location.

c) Limited Access

Only the researcher had access to identifiable data. Thesis supervisors accessed only anonymized data for supervision purposes. No identifying information about participants will be shared in publications or presentations.

d) Reporting Restrictions

Findings are reported in aggregate or using pseudonyms. Quotations included in Chapter Four are anonymized, sometimes with minor details changed to prevent identification while preserving substantive meaning.

e) Community Confidentiality

For community elders, additional confidentiality considerations arose given small community sizes where individuals might be identifiable even with pseudonyms. When quoting elders, potentially identifying information (specific medicinal plants, sacred knowledge, family relationships) was either removed or discussed only in general terms with explicit elder permission.

3.9. Researcher Positionality and Reflexivity

Qualitative research recognizes that researchers are not neutral, objective observers but bring their own identities, experiences, assumptions, and biases that inevitably influence all aspects of research. Reflexivity, critical self-awareness about these influences, is essential for quality qualitative research (Merriam and Tisdell, 2016). This section discusses the researcher's positionality and reflexive practices employed throughout the study.

3.10. Chapter Summary

This chapter has detailed the methodological approach employed to investigate how Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge, and how learners make meaning when engaging with both knowledge systems. Narrative inquiry provides the methodological framework, aligning with the study's emphasis on understanding lived experience through the stories participants tell. This qualitative priority is complemented by quantitative survey data in a mixed-methods design that provides both depth and breadth. The research setting encompasses selected secondary schools and communities in six Zambian provinces representing diverse urban, rural, and cultural contexts. Participants include 12 biology teachers, 8 community elders, and 126 learners in focus groups for qualitative inquiry, plus 55 teachers for the quantitative survey. Purposive sampling selected participants whose experiences would be particularly informative for addressing research questions.

Data collection employed semi-structured interviews with teachers and elders, focus group discussions with learners, and a survey of teachers. Each method was carefully

designed and implemented to gather rich, relevant data while respecting participants and following ethical protocols. Data analysis combined narrative analysis to preserve individual participants' stories and thematic analysis to identify patterns across participants. Qualitative analysis was iterative and recursive, moving between data and interpretation to develop well-grounded findings. Quantitative survey data received descriptive statistical analysis, with findings integrated at the interpretation stage to complement qualitative results. Trustworthiness and credibility were addressed through prolonged engagement, triangulation, member checking, thick description, audit trails, and reflexivity. The research received ethical clearance and followed rigorous ethical protocols regarding informed consent, confidentiality, minimizing harm, and respecting indigenous knowledge. Throughout the research, reflexive awareness of researcher positionality was maintained through journaling, peer debriefing, and memo writing. This reflexivity, while not eliminating researcher influence, makes it visible and manageable. The methodological approach described in this chapter provides a rigorous, culturally-appropriate framework for investigating the research questions. The resulting data and findings, presented in Chapter Four, offer rich insights into integration as a lived phenomenon, grounded in the experiences and perspectives of those most directly involved; teachers, community elders, and learners.

IV. Chapter Four - Presentation and Analysis of Findings

4. Introduction

This chapter presents the findings from the data collected to answer the main research question: How do Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge in biology education, and how do learners make meaning when engaging with both knowledge systems? The data, gathered through interviews, focus group discussions, and a questionnaire survey, are organized to address the three subsidiary research questions.

The chapter is structured into six main sections. First, section 4.1 delves into the lived experiences of biology teachers, presenting their narratives around integration supported by data tables. Second, section 4.2 centres the voices of community elders, sharing their perspectives on knowledge transmission and formal education with data tables from the file. Third, section 4.3 explores how learners experience and make meaning of biology lessons. Fourth, section 4.4 presents the quantitative survey results, revealing broader patterns in teacher attitudes and practices. Fifth, section 4.5 provides an integrated analysis, synthesizing findings from all participant groups. Finally, section 4.6 summarizes the key findings of the chapter.

4.1. Teacher Narratives of Integration

This section addresses subsidiary research question (a): What are the lived experiences of biology teachers who integrate indigenous and scientific knowledge in their teaching? Analysis of the 55 teacher responses organized around three central themes: (1) Pedagogical Strategies and Practices, (2) Navigating Epistemological Tensions and Contradictions (3) Challenges and Supporting Factors.

4.1.1. Pedagogical Strategies and Practices

Teachers who integrated IK employed a range of pedagogical strategies. The data revealed three primary approaches, each illustrated by specific teacher responses.

Table 1: (Table 4.1: Using Local Examples to Illustrate Scientific Concepts)

			Teacher's Observation of
			"Learners were very excited and provided different examples of atoms from their local communities"
			"The learner response has been awesome because I subject them to the flowers around the community for them to explore even more"
			"It enables learners to easily relate to the content being taught"
			"Learner responded positively by participating fully in the lesson"
			"Response from the learners was overwhelming and encouraging"

Table 2: (Table 4.2: Connecting Traditional Practices to Scientific Principles)

			Teacher's Explanation
			"In yeast there is an enzyme called zymase which breaks down sugar into alcohol and carbon dioxide. Carbon dioxide helps the dough to rise"
			"I explained how alcohol is learners back to science"
			"Plants manufacture their own

			Teacher's Explanation
			photosynthesis… These nutrients help plants produce important substances such as alkaloids, essential oils, tannins"
			"Traditional communities often designated certain forests as 'sacred'… This conservation strategy for biodiversity in Bemba land"
			"In the Tonga traditional integrate proteins"
			"It makes a male counterpart clean and more hygienical than uncircumcised one… prevents contraction of STIs"

Table 3: (Table 4.3: Inquiry-Based and Comparative Approaches)

			"Organisms of the same species are found together as a family… Observed through
			"Local materials needed may include; two balloons, three narrow tubes/pipes, empty disposable plastic bottle…

			illustrating the trachea and bronchi”
			“Learners are told to classify organism in the local languages”
			“Learners interview an elder Method of preparation”

4.1.2. Navigating Epistemological Tensions and Contradictions

Teachers navigate situations where IK and scientific knowledge appear to conflict in different ways, revealing their underlying epistemological beliefs.

Table 4: (Table 4.4: Pluralist and Complementary Navigation)

	Belief that herbal plants “magically cure” illnesses		“Such contradictions provide an opportunity to teach learners how to critically compare and integrate IK with scientific understanding”
			“Learners responded positively… they even started saying that there also natural medicine that can heal and treat some STIs”
		“I explained that the not a different defence”	

		"I have always enlightened them that some microorganisms are very useful… used as food, medicines, decomposers"	

Table 5: (Table 4.5: Viewing Contradictions as Pedagogical Opportunities)

			Teacher's Reflection
			"Despite these differences, such contradictions provide an opportunity to teach learners how to critically compare and integrate IK with scientific understanding"
			"This is because some information from IK was not scientifically proven… learners had false information on the subject matter"
			"Indigenous knowledge depends on observation and conclusion while science depends on observation, hypothesis, testing… analyzing data"

Table 6: (Table 4.6: Exclusivist and Dismissive Navigation)

		"It distorts mostly the delivery of lessons. This is so because learners tend to believe more the IK than what you deliver to them"	

		"Biology is a science which is based on facts that are scientifically proven, therefore it can not be incorporated with indigenous knowledge which is just exaggerated"	
		"Mostly it contradicts with Biology"	
		"It would distort biological facts with beliefs"	
		"Very knowledgeable in witchcraft and sorcery"	

4.1.3. Challenges and Supporting Factors

Teachers consistently reported several challenges to meaningful integration, as summarized in the tables below.

Table 7: (Table 4.7: Lack of Curriculum Guidance and Resources)

		"It doesn't encourage. The curriculum is silent on IK"
		"Because it is specific. We have to strictly teach according to the curriculum"
		"Limited time because of lack of clear curriculum guidance on indigenous knowledge integration"
		"Lack of teaching resources that clearly guide how to integrate IK into biology lessons"
		"Most of the indigenous knowledge has no documentation"
		"Few textbooks explain indigenous knowledge"

Table 8: (Table 4.8: Examination Pressure)

		"Because sometimes examiners have a way in which they want certain questions to be answered which puts learners at a disadvantage if they answer in their own way using IK"
		"Pressure to focus on examinable content"
		"Because examination questions do not accommodate answers with indigenous language and ideas"

Table 9: (Table 4.9: Practical Challenges (Time, Resources, Class Size))

		"The challenges faced were lack of materials to do experiments for learners who had never baked before"
		"Limited time to explore both indigenous and scientific perspectives deeply"
		"Large Numbers of pupils in classes which
		"Lack of proper infrastructure Lack of science material Lack of funding and support"
		"Availability of different types of species in the environment as many are in extinction"

Table 10: (Table 4.10: Teacher Knowledge and Confidence)

		"One challenge is that I don't always have deep enough knowledge of the local traditions myself, especially if I'm teaching in a community misrepresenting or oversimplifying"
		"Finding the suitable word for some local names and English words"

		"Some learners completely believe in what they tific knowledge they are learning"

4.2. Community Elder Perspectives

This section addresses a critical gap in the literature by presenting the perspectives of community elders, who are the custodians of indigenous knowledge. Analysis of the eight elder responses from the revealed three overarching themes: (1) The Nature and Erosion of Traditional Transmission, (2) Conditional Openness to Schools, and (3) Hopes and Fears for the Future.

4.2.1. The Nature and Erosion of Traditional Transmission

Elder participants vividly described a holistic, experiential system of knowledge transmission that has been profoundly disrupted.

Table 11: (Table 4.11: Traditional Methods of Knowledge Transmission)

		"Oral storytelling, observation, and participation in daily life… Elders would share wisdom during communal gatherings, ceremonies, and through proverbs"
		"Hands-on, practical fieldwork, reinforced by clear by doing, combined with guidance from elders and peers"
		"Story telling, Demonstration and engagement"
		"Through story telling and during initiation girls during modelling vessels"
		"From grandparents to grand children"
		"Through apprenticeship and storytelling around the
		"Through stories, observations"
		"Through organized evening talks, circumstantial events and reading story books, magazines and listening to radio shows"

Table 12: (Table 4.12: Elders' Observations on How Transmission Has Changed)

		"Formal education systems have become the main
		"Traditional knowledge, once passed mainly through hands-on practice and oral explanations, is now increasingly combined with modern methods and innovations"
		"Storytelling is replaced by technology e.g. TV programming, phones interactions"
		"Grandsons have been ignored most of the people have copied the western way of living and we treat elders as witches and wizards as long as they have grey hair"
		"Modern life has affected this. Children now watch more of TV"
		"Society is becoming increasingly culturally globalized hence different forms of knowledge and ways of accepting, using and transmitting it are prevalent"
		"Due to technologies young ones stick to watching
		"Western media has taken over much of the learning spaces and young ones are no longer interacting much with the elders"

4.2.2. Conditional Openness to Schools

Despite their concerns, elders expressed a strong but conditional openness to schools teaching traditional knowledge.

Table 13: (Table 4.13: Elders' Views on Teaching Traditional Knowledge in Schools)

		"It depends on how it is integrated. Teaching traditional knowledge alongside science can help students appreciate their cultural heritage… However, it should be

		done carefully to ensure accuracy and avoid misconceptions”
		“I believe schools should integrate traditional knowledge learning is just as new knowledge continually emerges to improve what we do; traditional knowledge provides a foundation rooted in culture”
		“Science has space in already existing traditions. the concept”
		“Yes, it should be included for preservation of our culture”
		“Traditional knowledge preserves Wisdom and knowledge”
		“It is imminent that traditional knowledge be introduced in schools and explored within learning context not only for sustainability but possibly novelty as well”
		“Because some tradition knowledge is needed in science”
		“Traditional knowledge is very vital and practically entirety”

Table 14: (Table 4.14: Knowledge Elders Consider Appropriate for Schools)

		“It helps learners link home practice to school activities”
		“On medicinal plants for example small pox… On farming animal waste was used as fertilizers”

		"Traditional medicine, food preservation should be taught"
		"Knowledge that can be questioned and ntexts"
		"Medicinal plants and their uses, traditional farming methods"
		"Hygiene, plants and their applications, importance, environmental stewardship"

Table 15: (Table 4.15: Knowledge Elders Consider Should Remain Private)

		"These are not just pieces of information—they carry deep meaning and identity, and sharing them outside the intended context could lead to misunderstanding or loss of respect for the culture"
		"To preserve respect, dignity, and authenticity. Keeping such knowledge private ensures that traditions are honoured and passed on responsibly, without losing their meaning or being misused"
		"Only things that risk behaviour and human health e.g. tattooing with one sharp instrument for multiple reasons"
		"No knowledge should remain private but that which is inconsistent and unverifiable should be refuted"

Table 16: (Table 4.16: How Elders Believe Schools Should Work with Them)

Elder ID	How Schools Should Work with Elders
	"Schools should work with elders through collaboration and mutual through storytelling sessions, practical demonstrations, and cultural days. Schools should also create spaces where elders feel valued, such as advisory committees or partnerships in curriculum development"
	"Schools should actively involve elders as partners in education… invited as guest speakers… engaged in storytelling sessions… organize intergenerational programs… play a role in curriculum development… crafts"
	"Invite as guest speaker and adopt them for apprenticeship and skill sharing"
	"Elders teach practical skills Story telling sessions in schools Elders to be guest speakers in school for transfer of traditional knowledge"
	"Invite elders as guest speakers"
	"They must be part of learning ecosystems where they are engaged from time to time to provide topics into which inquiry should be made. They should also be engaged to demonstrate ancient technology which works"
	"Invite elders as guest speakers"
	"Elders help develop curriculum"

4.2.3. Hopes and Fears for the Future

The elders' narratives are infused with a deep hope for the future, tempered by a realistic fear of continued loss.

Table 17: (Table 4.17: Elders' Hopes for the Future of Traditional Knowledge)

	"My hope is that traditional knowledge will be preserved and respected

	taught, and practiced in ways that keep its meaning and value alive”
	“My hope for the future of traditional knowledge is that young people s. I dream that this knowledge will never be lost but instead preserved and strengthened through schools that actively integrate culture into their teaching”
	“Young people will value and build learning from their experience aspect”
	“Traditional knowledge won’t be lost and that our children should know our customs”
	“Young people will value their heritage”
	“A future where children take up traditional knowledge and refine it
	“Schools to preserve our culture”
	“That young people will value their heritage”

4.3. Learner Experiences and Meaning-Making

This section addresses subsidiary research question (b): How do learners experience and make meaning of biology education that engages both indigenous and scientific knowledge systems? Analysis of the 126 learner responses revealed three major themes: (1) Engagement and Relevance through Connection, (2) Navigation of Multiple Knowledge Systems, and (3) Identity, Validation, and Belonging.

4.3.1. Engagement and Relevance through Connection

A resonant finding is that learners found biology more interesting and relevant when it connects to their lives and communities.

Table 18: (Table 4.18: What Makes a Biology Lesson Interesting (Learner Perspectives)

	"The lesson connects to our daily life; therefore, it helps us to and environmental changes"
	"Because of the practicals and good explanation by teachers"
	"The teaching methods the teacher uses are very effective and efficient"
	"Methods of teaching, lessons may be made interesting when we do contribute more"
	"Activities - Taking part in biology activities such as going to lab for investigations makes me understand more"
	"When the teacher uses activities like experiments, pictures, and real-life examples. I enjoy learning biology when it explains how living things grow, survive, and interact with the environment"
	"When we do experiments. When the teacher uses real-life examples. diagrams, models, and videos"
	"A lesson with interactive simulations depicting real situations, videos and concepts on power points and hands on activities that arouses critical thinking"

Table 19: (Table 4.19: Learner Examples of How Biology Connects to Daily Life)

		"Helps us to understand how we inherit traits from our parents… why offsprings of the same family looks different"
		"The study of genetics helps us understand why children of the same family looks different"
		"Plants make their own food because they are autotrophs"
		"We learn about things like digestion which takes place in living organisms nearly every day"
		"At home we were taught ways on how to maintain hygiene"

		"Learning about Reproduction helps to understand the beginning of new life"
		"Helps me to know how to take care of my body and understand body reactions"
		"Learning about how diseases are spread helps me know how to protect myself from them"

Table 20: (Table 4.20: Learner Confirmation of Teachers Using Local Examples)

		"Yes, through farming materials for example traditional knowledge may be discussed during the use of local organic fertilizer like dried cow dung"
		"Traditional examples are seen when we talk about things like traditional medicines… farming system and nutrients needed for a healthy plant"
		"Yes, in production of medicine"
		"How to maintain Hygiene as a girl during as a piece of cloth"
		"In farming using C*hitemene* system where trees are cut and burned The ashes from the burn help to neutralize the acidity of the soil"
		"Helps me to know how to make traditional manure, for gardens"
		"Traditional ways of brewing beer using germinating seeds"

4.3.2.Navigation of Multiple Knowledge Systems

Learners displayed sophisticated ways of navigating between IK and science, actively comparing, contrasting, and integrating knowledge.

Table 21: (Table 4.21: Learner Reports of Traditional Knowledge Discussed in Class)

	"Turmeric contains curcumin, which helps with inflammation and potentially blood sugar regulation"	
	"An individual having a terrible cough can utilize herbal remedies such as eating boiled lemon peels for healing and wellness"	
	"How people in the community uses herbs to treat different diseases"	
	"Use of local organic fertilizer like dried cow dung, dried grass and general traditional herbal manures"	
	"Traditional medicines and what makes them unique, farming system and nutrients needed for a healthy plant"	
	"Making local beverage like Munkoyo, Kachasu"	
	"Medicinal use of plants"	
	"How to maintain Hygiene as a girl during menstruation by using locally available materials such as a piece of cloth"	
	"Farming using *Chitemene* system where trees are cut and burned"	
	"Preserving drying fish"	
	"Animal breeding"	
	"Traditional ways of brewing beer using germinating seeds"	

Table 22: (Table 4.22: Learner Views on Whether IK and Science Can Work Together)

		"Combining IK and science enhances biodiversity conservation. It also enhances climate change adaptation strategies"
		"They both offer a deep understanding of local environment changes, aiding in reduction of disaster risks and building resilience"
		"What people understand traditionally can now be explained and understood in details using scientific knowledge"
		"Indigenously farmers who own farms can use fertilizers made from science components to have better soil quality and yield of crops"
		"Like when we talk about reproduction in living
		"Science and indigenous life talk about the same things in terms of living and non-living organisms"
		"It can be seen in the process of photosynthesis… we see how water and sunlight can be used in photosynthesis everyday"
		"It helps us understand the daily processes that take place and their purposes e.g digestion, photosynthesis and reproduction"
		"Living things enable to make their own food though a biological process known as photosynthesis that connects to science"
		"It connects the known local practices to the unknown which are scientific theorems"
		"When the knowledge is applied the end results are the same e.g. application of herbs to heal wounds"
		"Traditional doctors sometimes help scientist to identify the right herbs to make medicine"

Table 23: (Table 4.23: Learner Identification of Contradictions Between IK and Science)

	"The gender of a child is influenced by a woman which is not the case"	ntifies contradiction; finds lesson helpful for "clearing misconception"
	"Because in tradition they is witchcraft"	
	"Science uses chemicals while indigenous	
	"Science cannot be compared to traditional things because it is based on facts that are scientifically proven"	
	"Cause organic fertilizer has side effects to the soil causing soil erosion while inorganic doesn't"	

4.3.3. Identity, Validation, and Belonging

The emotional and identity-related impact of integration was profound. When their culture is included and valued, learners reported overwhelmingly positive feelings.

Table 24: (Table 4.24: Learner Feelings When Culture is Included in Lessons)

		"It fosters a profound sense of validation, pride and increased engagement"
		"It generally leads to the feeling of being valued and fosters a sense of pride and increased engagement"
		"Very good because I know for sure that our
		"Connected because it helps me to gain better understanding not only at home and at school on my culture and understanding"
		"I feel very interested and eager to learn more
		"Proud"
		"I feel fascinated"

		"I feel connected because learning a lesson that connects to my culture provides a sense of part of belonging that brings delightness"
		"Interested and connected"
		"Interested, because I would want to learn about my culture and how others think about it"
		"It enlightens me because I get to know about where I come from"
		"Proud"
		"It feels uncomfortable because people have different beliefs and views"
		"Happy"
		"Happy"
		"Connected"
		"Connected to reality"
		"I feel happy"
		"Interested"
		"Interested and feel connected"
		"It feels very good because it gives a sense of belonging"

Table 25: (Table 4.25: Learner Experience of Negative Feelings When Culture is Dismissed)

		"It feels Great when we are taught about what we know from our childhood. But it feels bad when the teachers talk about our culture just to make us feel that our tradition is worthless"
		"It feels uncomfortable because people have different beliefs and views"

		"It feels good when it is described positively and bad when described negatively"

4.4. Survey Results - Broader Patterns

This section addresses subsidiary research question (c): What broader patterns exist in teacher attitudes and practices regarding indigenous knowledge integration across the wider sample? The survey of 55 biology teachers provided quantitative data that contextualizes the qualitative narratives.

4.4.1. Teacher Demographics and Background

Table 26: (Table 4.26: Teacher Demographic Profile (n=55)

4.4.2. Teacher Attitudes and Beliefs

Table 27: (Table 4.27: Teacher Attitudes Toward Indigenous Knowledge (n=55)

4.4.3. Self-Reported Integration Practices

Table 28: (Table 4.28: Frequency of IK Integration (n=55)

Table 29: (Table 4.29: Types of Integration Practices Used (n=55)

4.4.4. Perceived Barriers and Supports

Table 30: (Table 4.30: Barriers to IK Integration (n=55)

4.4.5. Relationship Between Experience and Practice

Table 32: (Table 4.32: Integration Practice by Teaching Experience)

4.5. Integrated Analysis

Synthesizing the findings from teachers, elders, and learners through the data tables revealed a coherent yet complex picture of IK integration in Zambian biology education. This integrated analysis highlights the key dynamics and tensions that define the current landscape, with each finding now firmly grounded in the tabulated data.

Table 33: (Table 4.33: Triangulation of Key Findings Across Participant Groups)

	Teachers report learners have “false information” (ID 39)		
			Learners appreciate elders’

Table 34: (Table 4.34: The Spectrum of Teacher Navigation Strategies)

Table 35: (Table 4.35: Learner Meaning-Making Strategies)

4.6. Chapter Summary

This chapter has presented a comprehensive analysis of the data collected from Zambian biology teachers, community elders, and secondary school learners, supported by extensive data tables drawn directly from the three Excel data files.

Teacher narratives (Section 4.1, Tables 4.1-4.10) revealed a spectrum of pedagogical strategies, from using local examples (Table 4.1) to fostering critical inquiry (Table 4.3), and a parallel spectrum of ways to navigate epistemological tensions (Tables 4.4-4.6). Their efforts, however, are consistently hampered by systemic challenges, particularly lack of curriculum guidance (82% of teachers, Table 4.30) and examination pressure (78%, Table 4.30).

Community elders (Section 4.2, Tables 4.11-4.17) provided a crucial perspective. They unanimously confirmed the erosion of traditional transmission (Table 4.12) but expressed strong, conditional openness to partnership with schools (Table 4.13). Their conditions include respect, genuine collaboration, and the protection of sacred knowledge (Tables 4.14-4.16).

Learner experiences (Section 4.3, Tables 4.18-4.25) demonstrated that they are active meaning-makers who feel deeply engaged and validated when their culture was included (Table 4.24). They see complementarity between knowledge systems (Table 4.22) but are also vulnerable to alienation if their culture was dismissed (Table 4.25).

Finally, the survey results (Section 4.4, Tables 4.26-4.32) contextualized these findings, revealing a significant gap between positive attitudes (80%+ value IK, Table 4.27) and infrequent, often superficial, integration practices (only less than 20% integrate often, Table 4.28). The primary barriers identified were systemic (Table 4.30), confirming that individual teacher effort was insufficient without structural change. The integrated analysis (Section 4.5, Tables 4.33-4.35) synthesizes these findings, revealing a landscape of unrealized potential. There was strong goodwill from all stakeholders, but this potential was constrained by a rigid educational system that provides no clear pathway, resources, or incentives for meaningful implementation. The next chapter will discuss the implications of these findings, draw conclusions, and offer recommendations for policy, practice, and future research.

V. Chapter Five - Discussion, Conclusions, And Recommendations

5. Introduction

This chapter discusses the findings presented in Chapter Four in relation to the research objectives and questions that guided this study. The purpose of this research was to develop deep, contextual understanding of how Zambian biology teachers and community elders experience and navigate the integration of indigenous and scientific knowledge systems, and how learners make meaning when engaging with both knowledge systems. The study was motivated by three critical knowledge gaps identified in Chapter One: the lack of documented teacher experiences with integration, the absence of community elder perspectives in educational discourse, and the limited

understanding of how learners make sense of education that engages multiple knowledge systems.

Section 5.1 discusses the findings in relation to each research objective, demonstrating how the data addresses the identified gaps. Section 5.2 presents the conclusions drawn from the study, directly responding to the research questions. Section 5.3 examines the implications of the findings for theory and practice, building on the significance articulated in Chapter One. Section 5.4 offers recommendations for various stakeholders, including teachers, curriculum developers, and policy makers. Section 5.5 revisits the limitations acknowledged in Chapter One and discusses their implications for interpreting the findings. Section 5.6 suggests directions for future research, and Section 5.7 provides final reflections on the study's contribution to more equitable and culturally-responsive biology education in Zambia.

Throughout this discussion, the findings are interpreted through the lens of the theoretical framework established in Chapter Two, which combined epistemological pluralism, cultural-historical activity theory, and post-colonial theory. The discussion also returns to the key concepts defined in Chapter One, indigenous knowledge, integration, culturally-responsive pedagogy, and decolonization, to examine how the findings illuminate these constructs in practice.

5.1. Discussion of Findings

5.1.1. Teacher Experiences of Integration

The first subsidiary research question asked: What are the lived experiences of biology teachers who integrate indigenous and scientific knowledge in their teaching? The findings presented in Section 4.1 and Tables 4.1 through 4.10 revealed a complex landscape of teacher experiences characterized by diverse pedagogical strategies, varied approaches to navigating epistemological tensions, and consistent challenges related to systemic constraints.

5.1.1.1. Pedagogical Strategies and the Spectrum of Practice

The data showed that teachers employ a range of pedagogical strategies when attempting integration. Table 4.1 documented how teachers used local examples to illustrate scientific concepts, with Teacher ID 46 using local flowers to teach reproduction. Table 4.2 illustrated how teachers connect traditional practices to scientific principles, such as explaining the science behind traditional brewing (ID 45, 46) or the medicinal properties of plants (ID 48, 53). Table 4.3 revealed that a smaller number of teachers employed inquiry-based approaches, including building models from local materials (ID 36) and using local languages for classification (ID 16).

These findings directly addressed the first research gap identified in Chapter One: the lack of documented teacher experiences with integration. The data provided concrete evidence that some Zambian biology teachers were actively working to bridge knowledge systems, despite receiving minimal training or support. The pedagogical strategies documented aligned with what Aikenhead (2006) described as 'border crossing' approaches, where teachers facilitate learner movement between different cultural knowledge systems. However, the predominance of additive strategies (using

local examples) over more transformative approaches (comparative investigations) suggested that most teachers were operating at what might be considered the entry level of integration practice.

This finding echoes with the literature reviewed in Chapter Two. Snively and Corsiglia (2001) noted that superficial multiculturalism, which adds indigenous content without transforming pedagogy, was common when teachers lacked adequate preparation and support. The survey data in Table 4.29 confirmed this pattern, showing that 69.1% of teachers often used local examples, while only 5.5% often design comparative investigations. This gap between additive and transformative practice reflected the practical constraints teachers face and stresses the need for more comprehensive professional development, as discussed in Section 1.5.2 of Chapter One.

5.1.1.2. Navigating Epistemological Tensions

The findings revealed that teachers navigated epistemological tensions in distinctly different ways. Tables 4.4 through 4.6 documented this spectrum, from pluralist approaches that seek complementarity, to viewing contradictions as pedagogical opportunities, to exclusivist approaches that dismiss indigenous knowledge entirely.

Teachers who adopted pluralist approaches, such as ID 48 who used contradictions as opportunities for critical thinking, demonstrated the kind of epistemological awareness that Ogunniyi (2007) described in his contiguity argumentation theory. These teachers recognized that indigenous and scientific knowledge emerge from different worldviews but could productively coexist in educational settings. Their practices align with the epistemological pluralism framework discussed in Section 2.1.1 of Chapter Two, which holds that multiple legitimate ways of knowing exist and can be respectfully engaged in education.

However, teachers who adopted exclusivist approaches, such as ID 33 who viewed indigenous knowledge as distorting lesson delivery, or ID 24 who dismissed it as "exaggerated," reflect the continued influence of colonial-era hierarchies that position Western science as superior. As discussed in Section 1.1.1 of Chapter One, formal education systems in Zambia have historically devalued indigenous knowledge, presenting Western science as the only legitimate way of knowing. The persistence of exclusivist beliefs among some teachers demonstrated how deeply these colonial legacies are embedded in educational practice.

The finding that teachers' epistemological beliefs directly shaped their integration practices confirms what the literature suggested. Aikenhead and Ogawa (2007) argued that teachers' views on the nature of science and the validity of other knowledge systems fundamentally influenced their pedagogical choices. The current study provides empirical evidence from the Zambian context that supports this claim, addressing the gap identified in Chapter One regarding the need for contextual understanding of teacher experiences.

5.1.1.3. Challenges and Systemic Constraints

Tables 4.7 through 4.10 documented the challenges teachers face when attempting integration. The most frequently cited barriers were lack of curriculum guidance (82%

of survey respondents), examination pressure (78%), and insufficient teaching resources (70%). These findings directly address the research objective of identifying factors that constrain teachers' efforts.

The lack of curriculum guidance is particularly significant given the policy context discussed in Section 1.1.3 of Chapter One. While the Zambian Education Curriculum Framework (2013) explicitly calls for integration of indigenous knowledge, the data shows that this policy commitment had not translated into practical classroom support. Teachers described the curriculum as 'silent on IK' (ID 9) and 'specific' (ID 32), leaving them to navigate integration on their own. This gap between policy rhetoric and classroom reality confirmed the observation in Chapter One that implementation remains limited and inconsistent.

Examination pressure emerged as another critical constraint. As Teacher ID 10 explained, 'examiners have a way in which they want certain questions to be answered which puts learners at a disadvantage if they answer in their own way using IK.' This finding validates the concern raised in Section 1.1.4 of Chapter One that assessment practices focused exclusively on Western scientific knowledge provide no incentive for teachers to invest time in integration. The examination system, as a key component of the cultural-historical activity system described in Chapter Two, actively works against integration by rewarding only one type of knowledge.

The finding that teachers lack resources and documented materials for integration (ID 18, 21) confirms the observation in Chapter One that teacher training programs rarely address how to identify, validate, and incorporate indigenous knowledge. Without accessible resources, integration remains dependent on individual teacher initiative and creativity, making it unsustainable and inconsistent across schools and classrooms.

5.1.2. Community Elder Perspectives

The research problem articulated in Chapter One identified that community elders, the primary custodians and transmitters of indigenous knowledge, had rarely been asked about their perspectives on formal education's engagement with their knowledge. The findings presented in Section 4.2 and Tables 4.11 through 4.17 directly addressed this gap by centring elder voices and documenting their observations, concerns, and hopes.

5.1.2.1. The Erosion of Traditional Transmission

Table 4.11 documented the rich traditional methods of knowledge transmission that elders described, including oral storytelling, apprenticeship, observation, and participation in daily life. These descriptions aligned with the characterization of indigenous knowledge in Section 1.1.1 of Chapter One as holistic, place-based, and transmitted through intergenerational relationships. Elder ID 8's description of knowledge passed 'through oral storytelling, observation, and participation in daily life' echoed the literature on indigenous knowledge systems reviewed in Chapter Two.

However, Table 4.12 revealed that all eight elders unanimously agreed that traditional transmission had changed. The explanations they provided point to formal education, technology, and westernization as primary drivers of this change. Elder ID 6 stated simply, 'Storytelling is replaced by technology.' Elder ID 5 observed that 'grandsons

have been ignored… people have copied the western way of living.' These observations confirmed the concern raised in Chapter One that younger generations increasingly pursue formal education and urban employment, reducing opportunities for learning from elders.

The elders' accounts of transmission erosion provided empirical evidence for what the literature described as a crisis of cultural continuity. As discussed in Section 1.1.1, this devaluation has led many community members to dismiss traditional knowledge. The elders' voices in this study give human dimension to this crisis, revealing not just knowledge loss but also the pain of being ignored and devalued. Elder ID 5's emotional observation that 'we treat elders as witches and wizards as long as they have grey hair' captures the profound shift in intergenerational relationships that formal education has, perhaps unintentionally, produced.

5.1.2.2. Conditional Openness to Schools

Perhaps the most significant finding from the elder data is that they were not opposed to schools teaching traditional knowledge. Table 4.13 showed that all eight elders supported inclusion, though with important conditions. This finding challenges any assumption that communities resist engagement with formal education and instead reveals a willingness to collaborate that schools have not adequately recognized or responded to.

The conditions elders articulated are detailed in Tables 4.14 through 4.16. They distinguished between knowledge appropriate for schools, such as farming techniques, medicinal plants, and environmental stewardship, and knowledge that should remain private, including sacred rituals, secret ceremonies, and family-specific traditions. This distinction addresses directly the question raised in Chapter One: 'What kinds of knowledge do they consider appropriate or inappropriate for school inclusion?' The elders' clear articulation of this boundary provides essential guidance for ethical integration.

Elder ID 8 explained why certain knowledge must remain private: "These are not just pieces of information, they carry deep meaning and identity, and sharing them outside the intended context could lead to misunderstanding or loss of respect." This statement reveals the fundamentally different conception of knowledge that underlies indigenous knowledge systems. As discussed in Section 2.2.2 of Chapter Two, indigenous epistemologies emphasize that knowledge is embedded in relationships and carries responsibilities. Extracting it from its context, as schools are prone to do, risked distorting and devaluing it.

The elders' vision for how schools should work with them, documented in Table 4.16, provides a practical framework for partnership. Elder ID 7 called for schools to "actively involve elders as partners in education," including as guest speakers, in storytelling sessions, in intergenerational programs, and in curriculum development. Elder ID 8 suggested "advisory committees or partnerships in curriculum development." These recommendations directly respond to the concern raised in Chapter One about who has authority to determine which indigenous knowledge is

valid for school inclusion. The elders are not asking to be consulted; they are asking to be partners.

5.1.2.3. Hopes and Fears for the Future

Table 4.17 documented the elders' hopes for the future of traditional knowledge. Their aspirations centre on preservation, respect, and intergenerational transmission. Elder ID 8 hoped that traditional knowledge "will be preserved and respected for generations to come" and "not be seen as less important than modern science." Elder ID 7 dreamed that "this knowledge will never be lost but instead preserved and strengthened through schools that actively integrate culture into their teaching".

These hopes are tempered by fears of continued loss, evident in their observations about transmission erosion. The elders' dual perspective, hope for the future alongside fear of loss, captures the precarious position of indigenous knowledge in contemporary Zambia. Their willingness to engage with schools, despite their concerns, represents an invitation that the education system had not yet adequately accepted.

5.1.3. Learner Experiences and Meaning-Making

The third research gap identified in Chapter One was the lack of understanding of how learners make sense of education that engages both indigenous and scientific knowledge systems. The findings presented in Section 4.3 and Tables 4.18 through 4.25 provide rich data on learner experiences, directly addressing this gap.

5.1.3.1. Engagement Through Connection

Table 4.18 documented what makes biology lessons interesting for learners. Their responses consistently emphasized connection to daily life, practical activities, and real-world examples. Learner ID 126 captured this clearly: "The lesson connects to our daily life; therefore, it helps us to understand nature and how we interact with natural processes". Table 4.19 provided specific examples of how learners were seeing biology connecting to their lives, including genetics explaining family resemblance, digestion occurring daily, and reproduction observable in local animals.

Table 4.20 confirmed that learners recognized when teachers use local examples. This finding validates the promise of integration discussed in Section 1.1.4 of Chapter One: that connecting academic learning to familiar contexts enhances engagement and motivation. The learners' enthusiastic responses to local examples suggested that integration was achieving its intended effect of making science education more culturally relevant and meaningful.

The theoretical significance of this finding relates to culturally-responsive pedagogy, discussed in Section 1.5.1 of Chapter One. Gay (2010) argued that using cultural knowledge as a scaffold for learning improves academic achievement. The learner data in this study provides empirical support for this claim in the Zambian context, showing that learners were more engaged when their cultural knowledge was recognized and valued in the classroom.

5.1.3.2. Navigating Multiple Knowledge Systems

Table 4.21 documented the traditional knowledge learners reported discussing in class, including medicinal plants, traditional farming, food preservation, and animal

husbandry. This diversity of topics demonstrated that integration, when it occurred, touched on multiple domains of indigenous knowledge relevant to biology education.
Table 4.22 revealed that most learners saw indigenous knowledge and science as working together. Their explanations showed sophisticated understanding: "What people understand traditionally can now be explained and understood in details using scientific knowledge" (ID 88); "It connects the known local practices to the unknown which are scientific theorems" (ID 71). The learners were not confused by the presence of two knowledge systems. Rather, they saw them as complementary, with science providing deeper explanation for practices they already knew.
This finding directly addressed the question raised in Chapter One about how learners navigate apparent contradictions. The data showed that learners were capable of what Jegede (1995) called collateral learning, holding multiple knowledge systems simultaneously and using them in different contexts. However, Table 4.23 also documented that some learners identified contradictions. Learner ID 43 noted a contradiction between traditional belief about gender determination and scientific explanation, finding the lesson helpful for 'clearing misconception.' Learner ID 35 held an exclusivist view, stating that 'science cannot be compared to traditional things because it is based on facts.'

The range of learner responses, from complementarity to critical evaluation to exclusivism, demonstrated that meaning-making was not uniform. Learners arrive at different understandings based on their prior knowledge, cultural backgrounds, and the quality of the integration they experienced. This diversity confirms the importance of understanding learner meaning-making processes, as called for in Chapter One.

5.1.3.3. Identity, Validation, and Belonging

Table 4.24 documented the powerful emotional responses learners experience when their culture was included in lessons. Words like 'proud', 'happy', 'connected', 'validated', and 'engaged' appeared repeatedly. Learner ID 126 spoke of "a profound sense of validation, pride and increased engagement." Learner ID 81 felt "connected because learning a lesson that connects to my culture provides a sense of part of belonging."

These findings speak directly to the concern raised in Chapter One about the painful disconnection learners experience when the knowledge valued in their homes is absent from school. When schools validate indigenous knowledge, learners feel seen, respected, and affirmed. The integration of indigenous knowledge is not merely a pedagogical strategy; it is an act of recognition that has profound implications for learner identity and self-worth.

Table 4.25 provided the sobering counterpoint. Learner ID 37 described the dual experience: "It feels great when we are taught about what we know from our childhood. But it feels bad when the teachers talk about our culture just to make us feel that our tradition is worthless." This single statement encapsulates both the promise and the risk of integration. Done well, it affirms identity. Done poorly, it reinforces the very hierarchies it seeks to dismantle.

This finding validates the social justice significance articulated in Section 1.5.4 of Chapter One. Education that honours learners' cultural knowledge alongside scientific knowledge offers possibilities for maintaining strong cultural identities. It counters assimilationist models that require learners to abandon their heritage to succeed academically. The learners' voices in this study demonstrated that integration, when done respectfully, achieves this goal.

5.1.4. Broader Patterns in Teacher Attitudes and Practices

The third subsidiary research question asked: What broader patterns exist in teacher attitudes and practices regarding indigenous knowledge integration across the wider sample? The survey findings presented in Section 4.4 and Tables 4.26 through 4.32 provided quantitative data that contextualizes the qualitative narratives.

5.1.4.1. Positive Attitudes, Limited Practice

Table 4.27 showed that over 80% of teachers agreed or strongly agreed that indigenous knowledge was valuable and should be included in biology teaching. This finding demonstrated strong attitudinal support for integration among Zambian biology teachers. It suggested that the call for culturally-responsive education discussed in Section 1.1.3 resonated with teachers' own beliefs about good practice.

However, Table 4.28 revealed a significant gap between attitudes and practice. Only 20% of teachers reported integrating indigenous knowledge often or very often, while 54.5% did so only occasionally. This gap confirmed the observation in Chapter One that despite policy commitments, implementation remained limited. It also validated the elders' observation that schools were not yet adequately engaging with indigenous knowledge.

Table 4.29 provided more detail on practice patterns, showing that 69.1% of teachers often use local examples to illustrate concepts, while only 7.3% often invite elders and 5.5% design comparative investigations. This pattern confirms the qualitative finding that most integration is additive rather than transformative. Teachers are doing what is easiest and least resource-intensive, not what is most meaningful or epistemologically rich.

5.1.4.2. Systemic Barriers and Needed Supports

Table 4.30 documented the barriers teachers perceive to integration. The top three, lack of curriculum guidance (82%), examination pressure (78%), and insufficient resources (70%), were all systemic in nature. These were not barriers that individual teachers could overcome through personal effort. They required systemic responses from curriculum developers, examination bodies, and education authorities.

Table 4.31 showed the supports teachers identify as important. Clear curriculum guidelines and exemplars (85%) topped the list, followed by professional development (80%) and access to documented resources (75%). These findings directly inform the practical significance discussed in Section 1.5.2 of Chapter One. Teacher educators and professional development providers now have empirical evidence of what teachers need to integrate effectively.

The consistency between the barriers teachers identified and the support they requested validates the research approach. By asking teachers directly about their experiences, the study has generated practical knowledge that can inform targeted interventions. This addresses the gap identified in Chapter One: that teacher education programs lack empirical grounding for preparing teachers to integrate knowledge systems.

5.2. Conclusions

This study set out to answer one main research question and three subsidiary questions. The conclusions are organized around these questions, demonstrating how the findings resolve each one.

5.2.1. Main Research Question

How do Zambian biology teachers and community elders navigate the integration of indigenous and scientific knowledge in biology education, and how do learners make meaning when engaging with both knowledge systems?

The study concludes that integration is navigated through a complex interplay of teacher agency, community willingness, and systemic constraint. Teachers navigate integration by employing diverse pedagogical strategies that range from using local examples to designing comparative investigations. Their navigation is shaped by their epistemological beliefs, which influence whether they approach integration as complementarity, as pedagogical opportunity, or as threat to scientific teaching.

Community elders navigate integration from outside the formal system, observing its effects on knowledge transmission and expressing conditional openness to partnership. They navigate by distinguishing knowledge appropriate for schools from knowledge that must remain private, and by articulating visions for how schools should work with them; visions that centre respect, collaboration, and shared authority.

Learners make meaning by actively comparing, contrasting, and integrating the knowledge systems they encounter. Most see indigenous knowledge and science as complementary, with science providing deeper explanation for familiar practices. Their meaning-making is profoundly shaped by whether their culture is validated or dismissed in the classroom. When included respectfully, learners experience pride, connection, and a sense of belonging. When excluded or dismissed, they feel alienated and devalued.

The study concludes that integration, as currently practiced, is characterized by unrealized potential. All stakeholders recognize its value, but systemic barriers prevent meaningful implementation. Teachers attempt integration despite lack of support. Elders wait to be invited as partners. Learners hope their knowledge will be respected. The pieces for meaningful integration exist, but they are not yet intertwined into a coherent educational practice.

5.2.2. Subsidiary Research Questions

a) What are the lived experiences of biology teachers who integrate indigenous and scientific knowledge in their teaching?

The study concludes that teachers lived experiences are characterized by a gap between aspiration and reality. Teachers believe in the value of integration and observe its positive effects on learner engagement, but they are constrained by systemic barriers beyond their control. Their experiences are diverse, ranging from those who have developed sophisticated comparative pedagogies to those who dismiss indigenous knowledge entirely. However, the majority occupy a middle ground, using local examples when convenient but lacking the time, resources, and guidance to do more.
Teachers' experiences are also shaped by their navigation of epistemological tensions. Those who view indigenous and scientific knowledge as complementary find ways to present both respectfully. Those who view them as incompatible struggle to reconcile their teaching with their beliefs. The study concludes that teacher preparation and support must address not only practical strategies but also the epistemological questions that underlie integration.

b) How do learners experience and make meaning of biology education that engages both indigenous and scientific knowledge systems?

The study concludes that learners experience integration as deeply affirming when it is done respectfully. They feel pride, connection, and validation when their cultural knowledge is recognized in the classroom. They make meaning by actively comparing knowledge systems, and most conclude that the two systems complement each other. Learners are capable of sophisticated epistemological thinking, recognizing that science provides deeper explanation for practices they already know.

However, learners are also vulnerable. When their culture is dismissed, they feel that their traditions are considered worthless. This finding leads to the conclusion that integration carries significant responsibility. It is not merely a pedagogical choice but an act that shapes learner identity and sense of belonging. Teachers who attempt to include indigenous knowledge must do so respectfully, or risk causing harm.

c) What broader patterns exist in teacher attitudes and practices regarding indigenous knowledge integration across the wider sample?

The study concludes that while teacher attitudes strongly support integration, practice lags significantly behind. Over 80% of teachers value indigenous knowledge and believe it should be included, but only 20% integrate it often. The most common practice is using local examples, while more meaningful practices like inviting elders or designing comparative investigations are rare.

The barriers teachers identify are systemic: lack of curriculum guidance, examination pressure, and insufficient resources. The support they request is correspondingly systemic; clear guidelines, professional development, and documented resources. The study concludes that addressing the attitude-practice gap requires systemic intervention, not just exhortation of individual teachers.

5.2.3. Addressing the Research Problem

The research problem articulated in Chapter One identified three critical knowledge gaps: lack of documented teacher experiences, absence of community elder

perspectives, and limited understanding of learner meaning-making. This study has addressed each gap.

The documented teacher experiences in Section 4.1 provide rich understanding of how teachers navigate integration, the strategies they employ, the tensions they encounter, and the factors that support or constrain their efforts. These findings can inform teacher preparation and professional development, addressing the practical gap identified in Chapter One.

The community elder perspectives in Section 4.2 give voice to those historically excluded from educational discourse. Elders have articulated their observations about transmission erosion, their conditions for school engagement, and their hopes for the future. These perspectives provide essential guidance for ensuring that integration efforts are culturally appropriate, respectful, and aligned with community values.

The learner experiences in Section 4.3 reveal how learners make sense of education that engages both knowledge systems. They demonstrate that learners are active meaning-makers who feel deeply affirmed when their culture is included and deeply alienated when it is dismissed. These findings are crucial for designing integration approaches that achieve their intended goals of relevance, engagement, and cultural affirmation.

5.3. Implications for Theory and Practice

5.3.1. Theoretical Implications

The findings of this study have several implications for the theoretical frameworks discussed in Chapter Two.

a) Epistemological Pluralism

The study provides empirical support for epistemological pluralism as a framework for understanding integration. Teachers who successfully navigate integration demonstrate that indigenous and scientific knowledge can coexist and complement each other in educational settings. Learners who see the two systems as complementary show that pluralist understanding is attainable at the secondary level. However, the persistence of exclusivist beliefs among some teachers and learners suggests that pluralism is not automatic; it must be actively cultivated through education and experience.

b) Cultural-Historical Activity Theory

The findings confirm the utility of CHAT for analyzing integration as a culturally embedded activity. The systemic barriers teachers face, curriculum, examinations, resources, are components of the activity system that shapes teaching practice. The elders' knowledge transmission system operates according to different rules and tools, and the contradictions between these systems are productive sites for understanding why integration is so challenging. Any effort to promote integration must address the activity system, not just individual teacher knowledge or beliefs.

c) Post-Colonial Theory

The study provides compelling evidence of colonial legacies in Zambian education. Teachers who dismiss indigenous knowledge as superstition, elders who feel ignored and devalued, learners who have internalized that their culture is 'worthless', these findings demonstrate that colonial hierarchies persist in educational practice. However, the study also reveals agency and resistance. Elders articulate conditions for engagement. Teachers find ways to integrate despite lack of support. Learners feel proud when their culture is validated. These acts of resistance align with Bhabha's (1994) concept of hybridity, showing that new cultural forms can emerge from the encounter between knowledge systems.

5.3.2. Practical Implications

The findings have practical implications for the stakeholders identified in Chapter One.

a) For Practicing Biology Teachers

The documented pedagogical strategies in Tables 4.1 through 4.3 provide concrete examples that teachers can adapt to their own contexts. The spectrum of approaches, from using local examples to designing comparative investigations, offers entry points for teachers at different stages of integration. The finding that learners respond positively to integration should encourage teachers that their efforts are valued, even when systemic support is lacking.

b) For Teacher Educators and Professional Development Providers

The barriers and supports identified in Tables 4.30 and 4.31 provide clear guidance for program design. Professional development must address not only practical strategies but also the epistemological questions that underlie integration. It must prepare teachers to navigate the tensions that arise when knowledge systems appear to contradict. It must provide opportunities to learn from elders and to develop resources that are culturally appropriate and pedagogically sound.

c) For Curriculum Developers

The finding that 80+% of teachers cite lack of curriculum guidance as a major barrier is a clear call to action. Curriculum documents must move beyond general statements about valuing culture to provide specific guidance on how integration can be achieved. They should include exemplars, learning activities, and assessment strategies that incorporate indigenous knowledge. They should also address the distinction between public and private knowledge, drawing on the elders' wisdom documented in this study.

d) For Policy Makers

The examination pressure identified by 78% of teachers as a major barrier point to the need for assessment reform. As long as examinations test only Western scientific knowledge, integration will remain marginal. Policy makers must consider how assessment can value both knowledge systems without compromising standards. They must also address the resource constraints that limit teachers' ability to integrate meaningfully.

e) For Community Elders and Leaders

The findings validate the importance of elder voices in educational discourse. Elders' conditions for engagement, respect, partnership, protection of sacred knowledge, provide a framework for schools seeking to work with communities. The study

strengthens arguments for community involvement in education and provides evidence that elders are willing partners when approached appropriately.

f) For Learners

The ultimate implication of this study is for learners themselves. The findings show that learners want their culture to be valued in school. They respond with pride and engagement when it is appreciated. The practical implication is that schools should listen to learners, recognize their knowledge, and create educational experiences that affirm rather than alienate.

5.4. Recommendations

Based on the findings and conclusions of this study, the following recommendations are offered for various stakeholders.

5.4.1. Recommendations for the Ministry of Education

a) Develop Clear Curriculum Guidelines

The Ministry should revise curriculum documents to provide specific guidance on integrating indigenous knowledge into biology education. These guidelines should include; explicit learning, exemplar lessons, guidance on distinguishing public from private knowledge and suggestions for assessment strategies that value both knowledge systems.

b) Reform Assessment Practices

The Examinations Council of Zambia should explore ways to assess understanding of indigenous knowledge alongside scientific knowledge. This might include; questions that require comparison of indigenous and scientific explanations, projects that involve investigation of traditional practices and recognition of locally relevant knowledge in examination responses.

c) Support Professional Development

The Ministry should fund and support professional development programs that address integration. These programs should involve community elders as co-educators, address epistemological questions alongside practical strategies, provide ongoing support rather than one-time workshops and create networks of teachers committed to integration.

d) Develop Teaching Resources

The Ministry should commission the development of resources that support integration, including but not limited to documented case studies of successful integration, collections of local examples organized by concept/topic, lesson plans that incorporate indigenous knowledge and guidance on working respectfully with elders.

5.4.2. Recommendations for Teachers

a) Start Where You Are

Teachers should begin integration at whatever level feels comfortable, using local examples to illustrate concepts. As confidence grows, they can move toward more meaningful integration.

b) Learn from Communities
Teachers should take time to learn about the communities where they teach, including traditional practices, local plants and animals, and cultural protocols. This learning should be respectful and ongoing.

c) Invite Elders into Classrooms
Teachers should invite elders to share their knowledge, preparing them appropriately and ensuring they feel valued. Elders should be compensated for their time and expertise.

d) Address Contradictions Openly
When indigenous and scientific explanations differ, teachers should address this openly, using the tension as an opportunity for learning rather than dismissing either knowledge system.

e) Listen to Learners
Teachers should pay attention to how learners respond to integration, learning from their questions and reactions. Learners' experiences should guide ongoing refinement of practice.

5.4.3. Recommendations for Community Elders

f) Engage with Schools
Elders should accept invitations to share knowledge when schools approach respectfully. Their engagement is essential for meaningful integration.

g) Articulate Conditions Clearly
Elders should continue to articulate their conditions for engagement, including what knowledge can be shared and what must remain private. These conditions protect the integrity of indigenous knowledge.

h) Mentor Younger Generations
Elders should continue to transmit knowledge through traditional means, recognizing that school-based transmission complements but does not replace intergenerational learning.

i) Participate in Curriculum Development
When invited, elders should participate in curriculum development, ensuring that indigenous knowledge is represented accurately and respectfully.

5.5. Limitations and Their Implications

As acknowledged in Chapter One, this study has several limitations that affect interpretation of the findings.

5.5.1. Depth over Breadth

The study prioritized qualitative depth over quantitative breadth, with a relatively small number of participants in the narrative inquiry component. This means findings may

not be statistically generalizable to all Zambian biology teachers, elders, or learners. However, as Stake (1995) argued, narrative inquiry offers 'naturalistic generalization' based on experiential resonance rather than statistical probability. Readers can assess whether the experiences documented resonate with their own contexts and transfer accordingly. The survey component, with 55 teacher respondents, provides broader context but remains limited in its generalizability. The consistency between survey findings and qualitative narratives strengthens confidence in the patterns identified.

5.5.2. Self-Reported Data

The study relied primarily on self-reported experiences and perceptions gathered through interviews and surveys. While this approach is appropriate for understanding how participants make meaning of their experiences, it does not provide comprehensive documentation of actual classroom practices. Participants may have presented idealized versions of their practice, and what they report may not fully align with what they do. Future research could address this limitation through extended classroom observation and ethnographic methods. However, the consistency across multiple data sources, teachers, elders, learners, surveys, provides triangulation that strengthens confidence in the findings.

5.5.3. Language and Translation

Some meanings may have been lost in translation, particularly when elders discussed indigenous knowledge concepts lacking direct English equivalents. Efforts were made to conduct interviews in participants' preferred languages and to negotiate meanings carefully, but some details may remain untranslatable. The inclusion of research assistants from local communities helped address this limitation, as did member checking with participants to verify accuracy of representation.

5.5.4. Researcher Positionality

The researcher's positionality as a Zambian biology educator inevitably shaped the research process. While this insider status provided valuable contextual knowledge and cultural competence, it may also have created blind spots. Reflexivity practices, including journaling and peer debriefing, helped surface and manage these influences, but they cannot be eliminated entirely.

5.5.5. Focus on Formal Education

The study focused on integration within existing formal education structures rather than examining alternative or community-based models. This focus reflects the reality that most Zambian children's primary educational experience occurs in formal schools, but it may overlook other valuable approaches to knowledge transmission and integration.

5.5.6. Scope Limitations

The study examined biology education at secondary level rather than science education more broadly, and integration at secondary rather than primary level. The particular challenges and opportunities at other levels and in other subjects may differ, and findings should not be assumed to transfer without careful consideration.

5.6. Directions for Future Research

This study has addressed important gaps in understanding indigenous knowledge integration in Zambian biology education, but it has also revealed new questions that warrant investigation.

5.6.1. Classroom Observation Studies

Future research should include extended classroom observation to document actual integration practices, complementing the self-reported data in this study.

5.6.2. Longitudinal Studies

Longitudinal studies would track how teachers, learners, and elders change over time through sustained engagement with indigenous knowledge integration This is something this cross-sectional study could not capture. Following the same participants across multiple years would reveal whether integration efforts produce lasting effects on teaching practice, learner identity, and community perceptions, filling a critical gap in the current literature.

5.6.3. Comparative Studies

Comparative research could examine integration across different contexts, Urban versus rural schools, different provinces and cultural groups, government versus private schools and schools with strong community partnerships versus those without. Such comparisons could identify contextual factors that support or constrain integration and reveal patterns that transcend specific settings.

5.7. Final Reflections

This study began with a critical observation; that Zambian communities possess profound ecological wisdom developed over generations, yet formal biology education often sidelines this heritage as irrelevant. The research set out to understand how teachers, elders, and learners navigate this disconnect; how they experience, resist, and sometimes bridge the gap between knowledge systems.

The findings reveal a landscape of unrealized potential. Teachers believe in integration but lack systemic support. Elders are willing to share their knowledge but wait to be invited respectfully. Learners feel proud and engaged when their culture is included, alienated and devalued when it is dismissed. The pieces for meaningful integration exist, but they are not yet woven together into a coherent educational practice.

What this study makes clear is that integration is not merely a technical or pedagogical challenge. It touches fundamental questions of identity, power, and justice. When schools exclude indigenous knowledge, they perpetuate colonial hierarchies that position Western science as superior and African ways of knowing as primitive. When schools include indigenous knowledge respectfully, they affirm learners' identities, validate community wisdom, and work toward educational justice.

The elders in this study offered a vision for how schools should work with them; through collaboration and mutual respect, as partners in curriculum development, as guest speakers and storytellers, as teachers of practical skills rooted in heritage. This vision is not complicated or expensive. It requires only that schools recognize elders as knowledge holders and create spaces where they feel valued.

The learners in this study spoke clearly about what integration means to them. When their culture is included, they feel proud, connected, and engaged. When it is dismissed, they feel that their traditions are considered worthless. Their voices should guide every decision about integration. If it affirms learners, it is working. If it alienates them, it is causing harm.

The teachers in this study demonstrated that integration is possible even without systemic support. They found ways to use local examples, connect traditional practices to scientific principles, and sometimes design investigations that engage both knowledge systems. Their creativity and commitment should inspire others and should be supported through the systemic changes they identified.
This research contributes to the growing body of scholarship on epistemological pluralism, culturally-responsive pedagogy, and decolonizing education. But its deepest contribution may be simply this: it has created space for voices too often excluded from educational discourse. Elders have spoken about their knowledge and their hopes. Learners have shared what makes them feel proud and what makes them feel alienated. Teachers have described their struggles and their successes.

The task now is to listen to these voices and to act on what they say. The weavers of knowledge, teachers, elders, and learners, have shown us the pattern. It remains for the education system to provide the adoption and implementation platform.

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