Chapter # 20

A RELATIONAL FRAMEWORK FOR PROFESSIONAL DEVELOPMENT IN RURAL SCIENCE EDUCATION:
Integrating Ubuntu, indigenous knowledge, & inquiry-based practice

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ABSTRACT
This chapter examines how collaborative professional development can enhance Life Sciences teachers' practical work competencies in rural South African schools by integrating Indigenous Knowledge Systems, Ubuntu, and inquiry-based practice. The qualitative case study involved 25 Grade 10 and 11 teachers from twelve resource-constrained rural schools who were both convenient and purposively sampled. Data was generated through video and audio recorded observations, fieldnotes, focus group discussions, and written artefacts, which were all analysed thematically using constant comparison and triangulation. Findings reveal that teachers reconceptualised practical work when exposed to culturally grounded, embodied activities, such as ingoma (Zulu song/singing) and ukugida (Zulu dance), which linked communal cultural practices to scientific inquiry. Collaborative mapping of Indigenous Knowledge System-based practicals fostered professional creativity, epistemic engagement, and teacher agency, while Ubuntu principles underpinned relational learning, emphasising collective reflection, mentorship, and shared responsibility. Structural constraints, including workload, limited resources, and policy rigidity, were identified as barriers to sustained innovation. The chapter argues that sustainable PD in rural contexts requires recognising learners, teachers and subject advisors as pedagogical partners and knowledge brokers, creating relational, culturally responsive spaces that transform both teacher practice and the enactment of practical work in Life Sciences classrooms.

Keywords: life sciences education, teacher professional development, indigenous knowledge systems, rural education, Ubuntu; inquiry-based learning.

1. INTRODUCTION

Practical investigations are central to the South African Life Sciences curriculum because they cultivate learners' inquiry skills, scientific reasoning, and capacity to interpret empirical data (Department of Basic Education (DBE), 2011). Despite this emphasis, provincial diagnostic reports and school assessments consistently show underperformance in questions requiring experimental design, data analysis, and interpretation. Resource scarcity, teacher isolation, and short-term, exam-oriented workshops are frequently cited as contributing factors (Chuene & Xaba, 2024; Xaba et al., 2022, 2025), yet less attention has been paid to how professional development (PD) interacts with local epistemologies and the daily routines of rural classrooms. Rural teachers often negotiate between formal scientific knowledge and learners' cultural beliefs, practices, and lived experiences, resulting in practical work that is decontextualised or fails to leverage learners' prior knowledge and cultural capital.

Meaningful integration of IKS into Life Sciences education requires more than the addition of content, it demands pedagogical strategies that are inquiry-driven, contextually responsive, and culturally sensitive (Mlotshwa & Tsakeni, 2024). Such strategies foster collaboration, reflective learning, and ubuntu, emphasising relationality and collective growth among teachers and learners. However, rural teachers frequently lack targeted PD that equips them to enact these strategies effectively, limiting their ability to create meaningful, contextually relevant learning experiences. This chapter reports an empirical investigation that addresses these gaps by examining how a collaboratively designed PD programme influenced teachers' abilities to enact practical work in resource-constrained rural contexts.

The guiding research question for this empirically oriented chapter is the following: How can Life Sciences teachers' practical work competencies be enhanced through a collaboratively designed professional development programme that draws on inquiry practice, local indigenous knowledge, and ubuntu-informed relations, and what evidence demonstrates that change has occurred? This chapter proposes a relational professional development framework that is conceptually distinct from skills-based or compliance-oriented PD models. Rather than treating Ubuntu, IKS, and inquiry-based practice (IBP) as separate or additive approaches, the chapter theorises their integration as an ethical-epistemic-methodological configuration shaping how teachers learn, collaborate, and enact practice in rural science classrooms. Drawing from empirical evidence from a collaboratively designed PD initiative, the chapter demonstrates how relational conditions (Ubuntu), epistemic grounding (IKS), and pedagogical process (IBP) operate together to support meaningful and sustainable teacher learning and PD in under-resourced contexts.

2. THEORETICAL FRAMEWORK: SITUATING PROFESSIONAL DEVELOPMENT IN RURAL CONTEXTS

PD in rural South African contexts cannot be understood solely as formal workshops or policy compliance (Xaba, 2025). Scholars increasingly argue that teacher learning in these settings is relational, socially situated, and mediated by local knowledge systems (Hoadley & Jansen, 2018; Reddy & Motala, 2020). Rural teachers negotiate professional growth within resource constraints, cultural norms, and daily classroom practices, suggesting that effective PD must extend beyond technical skill-building to encompass ethical, epistemic, and pedagogical dimensions. In this chapter, a relational lens is adopted to conceptualise PD as emergent through collaborative, inquiry-oriented, and contextually responsive practices, integrating Ubuntu as an ethical framework, IKS as an epistemic resource, and Inquiry-Based Practice (IBP) as a methodological approach.

2.1. Ubuntu: Relational-Ethical Orientation

Ubuntu, commonly articulated as *umuntu ngumuntu ngabantu*, which translates as "a person is a person through others" and foregrounds interdependence, mutual respect, as well as collective responsibility in human interactions (Ngubane & Makua, 2021; Ramose, 1999). Within African philosophical thought, Ubuntu is both an ethical orientation and a social ontology, highlighting relationality as the foundation of knowledge, identity, and moral responsibility. In education scholarship, Ubuntu has been increasingly theorised as informing humanising pedagogies, culturally responsive teaching, and relationally grounded professional learning (Letseka, 2012; Radebe, 2023; Swanson, 2012).

Applied to teacher PD, Ubuntu reframes learning as a socially mediated process, where professional growth emerges through interactions, peer networks, mentorship, and collective reflection. In rural contexts, where teachers often face professional isolation, limited resources, and socio-cultural constraints, Ubuntu offers a framework for understanding how collaboration, trust, and mutual support can sustain teacher learning (Chikoko, 2013; Sayed, 2017). Empirical studies suggest that Ubuntu-informed PD cultivates relational resilience, encourages reflective practice, and fosters a sense of communal responsibility in education, enabling teachers to negotiate challenges collaboratively rather than individually (Radebe, 2023; Swanson, 2012).

2.2. Indigenous Knowledge Systems: Contextual and Epistemic Grounding

IKS encompass the locally rooted knowledge, practices, beliefs and technologies of communities, transmitted across generations and embedded within ecological, medicinal, agricultural and social contexts (Ahanonye, 2021; Hlalele, 2019). Such systems offer an epistemological foundation for situating science teaching within the cultural and ecological lifeworld's of learners (Mlostwa et al, 2024). In science education literature, IKS has been shown to enhance curricular relevance, learner engagement and epistemic diversity by legitimising forms of knowledge commonly marginalised in Western-centric schooling paradigms (Blackie, 2024; de Beer, 2012). For example, studies in South Africa reveal that integration of IKS can help bridge learners' everyday knowledge with formal scientific inquiry, thereby supporting stronger conceptual connections (Elekwa, 2022, 2024). Within PD contexts, IKS provides educators with tools to integrate local knowledge such as medicinal plants, agricultural knowledge, and traditional food preparation methods into Life Sciences instruction, not as superficial add-ons but as legitimate knowledge forms that complement scientific inquiry (Ahanonye, 2021; Handayani et al., 2019). By adopting IKS as a theoretical lens, PD can empower teachers to validate learners' cultural and social knowledge, thereby fostering pedagogical confidence and agency in rural contexts. In effect, IKS addresses both the "what" (the content grounded in local knowledge) and the "why" (the relevance and legitimacy of that content) of teaching and professional learning. For rural Life Sciences classrooms, where learners and teachers often operate within resource-constrained and culturally complex settings, integrating IKS means positioning teachers as custodians and translators of community knowledge into scientifically informed practice.

2.3. Inquiry-Based Practice: Methodological Dimension

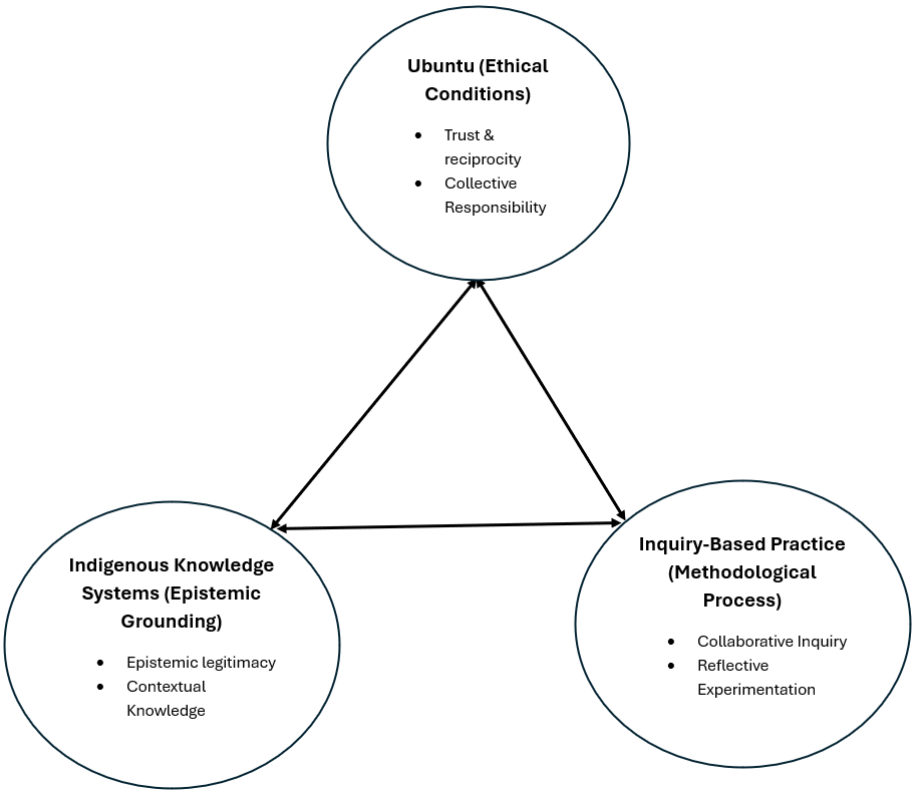
IBP positions teacher learning as an iterative, reflective, and participatory process that emphasises active engagement with content, learners, and the classroom environment (Scheurman & Marcon-Toutant, 2021). Rooted in constructivist principles, IBP frames knowledge construction as a dynamic cycle of questioning, experimentation, observation, reflection, and refinement (Crawford & Capps, 2018; Tal et al., 2019; Van Dusen et al., 2012). In the context of professional development, IBP shifts the focus from passive knowledge transmission to participatory, teacher-centred learning, where educators collaboratively explore pedagogical strategies, test classroom interventions, and reflect on outcomes to inform future practice (Kang & Kim, 2020; Krajcik & Blumenfeld, 2006).

Research indicates that IBP enhances both teacher and learner engagement by fostering critical thinking, and problem-solving skills (Crawford, 2014). In rural and resource-constrained settings, IBP is particularly valuable because it encourages teachers to co-design investigations using locally available materials and to adapt lessons to cultural and

environmental contexts (Tal et al., 2019; Van Driel et al., 2014). Such approaches not only support culturally responsive pedagogy but also empower teachers to integrate IKS into science teaching, bridging formal scientific concepts with learners lived experiences (Handayani et al., 2019; Mlotshwa et al., 2024).

In this chapter, Ubuntu (ethical condition), IKS (epistemic grounding), and IBP (methodological process) are conceptualised as mutually constitutive dimensions of PD rather than parallel theoretical lenses as illustrated in Figure 1 below.

Figure 1.
The relationship between Ubuntu, IKS and IBP as frameworks situating PD in rural contexts.



Together, these perspectives frame PD as relational, contextually grounded, and inquiry-driven, informing both the design of programme and the interpretation of empirical findings.

3. METHODOLOGY

This study adopted a Participatory Action Research (PAR) design embedded within a larger PD initiative facilitated by the University of Zululand in collaboration with the KwaZulu-Natal Department of Education. PAR was chosen because it prioritises collaboration, reflexivity, and shared ownership of knowledge, which are key principles that

resonate with Ubuntu and inquiry-based learning. The design followed iterative cycles of planning, action, observation, and reflection (Creswell, 2014), allowing the project to remain responsive to teachers' evolving needs and contextual realities.

Twenty-five Grade 10 and 11 Life Sciences teachers from twelve rural secondary schools in Zululand District participated in the study. Selection was purposive, focusing on schools characterised by resource scarcity, poor learner performance in School-Based Assessments (SBAs) for practical work, and geographic isolation. Teaching experience ranged from one to twenty-five years, capturing both novice and experienced perspectives. Four workshop cycles were conducted over one academic year, each comprising two-day sessions. Data was collected through:

i. Observations and filed notes which were taken during the workshop sessions
ii. Focus group sessions where participants and facilitators discussed ideas shared during the workshops
iii. Reflective discussions following each workshop cycle, where teachers evaluated activities and suggested improvements
iv. Written artefacts from groups which provided insights into teacher collaborative thinking and/or ideas

All the data was video and audio-recorded, transcribed verbatim, and analysed thematically. Qualitative data were summarised descriptively to identify broad patterns of teacher development across the year. Ethical clearance was granted by the University of Zululand Research Ethics Committee and the KwaZulu-Natal Department of Education. Informed consent was obtained from all participants, pseudonyms were used, and confidentiality was maintained throughout.

4. RESULT AND FINDINGS

To answer the research question which guided the study: How can Life Sciences teachers' practical work competencies be enhanced through a collaboratively designed PD programme that draws on inquiry practice, local indigenous knowledge, and ubuntu-informed relations, and what evidence demonstrates that change has occurred?

Three interrelated themes emerged from the data as follows:

i. Re-imagining practical work through cultural lenses
ii. Professional growth through collaborative inquiry and reflection
iii. Ubuntu as a foundation for transformative PD

These themes collectively illustrate how inquiry-based learning, IKS, and ubuntu can serve as interdependent frameworks for advancing teacher PD in rural Life Sciences education.

4.1. Re-imagining Practical Work Through Cultural Lenses

Across all data sources, participants demonstrated a profound epistemic shift in how they conceptualised Life-Sciences practical work particularly after engaging with a video recording of an Honours student conducting a culturally grounded practical on the circulatory system. The student used *ingoma* (**Zulu song**) and *ukugida* (**Zulu dance**) as embodied pedagogical tools to explore variations in heart rate and pulse during physical activity for their assignment presentation. This demonstration operated simultaneously as a scientific experiment and a cultural artefact that provoked deep reflection on the meaning of inquiry-based learning in African rural contexts.

During the recorded session (video observation), participants measured their pulse rates and listened to their heartbeats before and after dancing, recording data at intervals of 5, 10, 15, and 20 minutes using a stethoscope as shown in figure 2.

Figure 2.
Teachers working together during a practical task.

The teachers were also asked to repeat the steps without using the stethoscope but instead using their finger and ears to count the heartbeat and pulse rate. Their visible engagement depicted by laughter, collective counting of heartbeat and pulse rates signalled a genuine shift from passive reception to participatory and embodied learning. The integration of *ukugida* (**Zulu dance**) transformed the abstract notion of 'practical work' into a culturally resonant, community-based activity that connected bodily experience with scientific reasoning.

In the subsequent focus group discussion, teachers reflected on whether IKS could bridge the gap in practical work. The transcripts and field notes captured powerful expressions of conceptual transformation. One teacher reflected:

"If CAPS clearly stated these guidelines, or maybe if the Department trained us to think like this, then there would be no excuse for us not to do practicals using our Indigenous Knowledge and available resources."

This statement highlighted both systemic constraints and untapped pedagogical potential, revealing how teachers' dependence on curriculum directives contrasts with their recognition that IKS can provide low-cost, contextually meaningful opportunities for conducting practical work in resource-limited communities. Another teacher expressed:

*"Actually, this is a brilliant idea. Look at how our cultural practice such as ukugida [**Zulu dance**] can be used as a practical activity. My learners always sing Zulu songs and dance during break time, but it never occurred to me that I could use that in class as a practical. It requires very minimal resources; the learners themselves are a resource. I really enjoyed this, and it has opened my ears."*

Written artefacts from the group work corroborated these reflections, with teachers linking ukugida [**Zulu dance**] to Life Sciences topics such as the circulatory system, cellular respiration, and energy transformation. They identified other IKS-based practices such as fermenting umqombothi **[African beer]** and amahewu **[porridge**], preparing ujeqe [**steamed bread**], and ukubasa komlilo ngekhandlela [**fire making using a candle**] instead of Bunsen burners as other locally accessible alternatives to formal laboratory practicals to mention a few. These triangulated data sources (video observation, focus group discourse, and artefact analysis) collectively evidenced a paradigm shift in how teachers understood the purpose and possibilities of practical work in the IKS lens.

Interpreting these findings through the lenses of cultural inquiry-based learning and Ubuntu epistemology reveals the deep pedagogical significance of this shift. The ingoma **[Zulu song/singing]** practical exemplified key stages of scientific inquiry skills such as observation, prediction, testing, and explanation, yet it did so through a communal and embodied process aligned with Ubuntu principles of interdependence and shared knowledge creation. This supports Ogunniyi's (2007) assertion that African epistemologies can serve as mediating tools for scientific reasoning when engaged dialogically and resonates with Pedaste et al.'s (2015) model of inquiry as a contextual, evidence-based process of meaning-making.

However, not all responses were uncritical. Some participants raised legitimate concerns about policy alignment and assessment standards, noting that:

"We can do this, but CAPS doesn't show how to assess this IKS. We might be questioned for not following the policy strictly and sometimes time constraints are also a factor. But there is potential if all stakeholders buy into this idea, at least our subject advisor is also here…."

This tension highlights the persistent structural barriers that limit innovation in science teaching, particularly in rural contexts where accountability pressures and limited training constrain teachers' agency. The findings, therefore, shows the need for PD models that legitimise and institutionalise IKS-driven inquiry as a valid form of practical work, rather than treating it as a supplementary or informal approach.

4.2. Growth Through Collaborative Inquiry and Reflection

Building on the momentum generated by the *ingoma* and *ukugida* practical, teachers were divided into small groups and tasked with identifying ways IKS could be integrated into Life Sciences topics they currently teach as depicted by Figure 3.

Figure 3.
Teachers working in groups discussing ideas.

This activity functioned as both a collaborative reflection exercise and a practical application of the insights gained from the earlier demonstration. It provided a critical third layer of triangulation by capturing written artefacts, dialogue excerpts, and observed group interactions. The group task revealed strong evidence of emerging pedagogical innovation. Teachers drew direct connections between cultural practices and curriculum topics, generating a repertoire of contextually grounded practical ideas. For example, one group proposed linking food and nutrition to traditional foods such as ujeqe [Steamed bread], umqombothi [African beer], and usu [Tripe], suggesting these could be used to demonstrate concepts such as starch testing, fermentation, and enzymatic activity to mention a few. Another group mapped the topic of ecosystems to local indigenous plants and animals, proposing that learners investigate ecological interactions through direct observation of familiar species. Similarly, cellular respiration was connected to the fermentation of umqombothi [African beer], while photosynthesis was linked to indigenous flora such as umkhanyakude [Vachellia xanthophloea/yellow bark/fever tree], which could be used in simple experimental setups to test for the presence of starch in leaves.

These examples demonstrated a tangible move from theoretical endorsement of IKS to the practical re-imagining of laboratory work in resource-limited schools. What emerged across the groups was a shared realisation that authentic scientific inquiry does not rely on expensive apparatus or Western-standard laboratories; rather, it can draw meaningfully on locally available materials and lived experiences. The act of mapping their ideas collectively also revealed a social dimension to knowledge construction. Experienced teachers often took on mentoring roles, guiding novice teachers through the process of aligning indigenous practices with scientific concepts, which was an enactment of *Ubuntu* informed professional learning in real time. Field notes captured several *"aha moments"* during this phase, particularly among younger or less experienced participants who admitted they had never

considered the possibility of transforming routine cultural practices into scientific investigations. As one novice teacher noted, *"I've always thought practical work means having microscopes or chemicals, but now I see that practicals can start from what we already know and do in our communities."* This insight signifies more than resourcefulness; it signals a deepened epistemological understanding of science as a living practice embedded in cultural and ecological contexts.

When analysed collectively, these artefacts and reflections suggest that collaborative IKS-based curriculum mapping not only generated practical teaching ideas but also functioned as PD that was essential in cultivating teachers' confidence, creativity, and sense of agency. Interpreting these findings through IBP and Ubuntu frameworks, the collaborative exercise exemplified socially mediated professional learning. Inquiry, as conceptualised by Pedaste et al. (2015), is iterative, dialogic, and context sensitive. When embedded in Ubuntu-informed communities of practice, it transcends individual cognition, fostering shared meaning-making and mutual growth (Letseka, 2013). The teachers' dialogue and artefacts reflected this relational epistemology: knowledge was not transmitted but co-constructed through collective reflection on lived experiences.

4.3. Ubuntu as a Foundation for Transformative Professional Development

Ubuntu principles were visible not only in participants' reflections but in their interactions throughout the workshop. The video recordings captured collective singing, rhythmic unity, and spontaneous cooperation, which all are symbolic of communal learning. During focus group discussions, one teacher explained: *"We learn better when we teach each other; this reminded us that knowledge grows when it is shared and actually collaboratively, we have the potential of solving our problems."*

Other phrases such as *"We supported each other"* and *"Our strength is togetherness"* frequently appeared in the transcripts and/or analysis. These expressions demonstrate ubuntu's enactment as a lived professional value. Ubuntu provided moral and epistemic grounding for teachers' engagement. It transformed PD from an externally imposed intervention into a community of care and mutual accountability, echoing Letseka's (2013) and Waghid's (2018) assertions that ubuntu-based education nurtures human relationships as sites of knowledge creation. By weaving ubuntu into PD, teachers positioned themselves not as recipients of expert knowledge but as *custodians of collective wisdom*. This model of PD aligns with the decolonial imperative articulated by Le Grange (2019) that African education systems must reclaim relationality and interconnectedness as legitimate epistemic values.

5. FUTURE RESEARCH DIRECTIONS

The findings of this study highlight two avenues for future research aimed at deepening understanding of relational, culturally grounded PD in rural Life Sciences education as follows: (i) Scaling Ubuntu-Informed PD Models: Future research should explore the applicability of Ubuntu-informed, IKS-integrated PD across diverse rural contexts. Comparative studies across provinces could illuminate how socio-cultural and ecological variations shape teachers' adoption of inquiry-based practices and IKS and (ii) Policy Alignment and Institutional Support: Research should examine strategies to institutionalise culturally grounded PD including alignment with the CAPS, formal recognition of subject advisors as pedagogical partners, and integration into provincial PD frameworks. By addressing these directions, research can further consolidate a relational framework for sustainable, contextually relevant science education, promoting both professional and epistemic justice in rural South African classrooms.

6. CONCLUSION/DISCUSSION

The triangulated findings of this study point to a significant re-conceptualisation of Life Sciences practical work and, by extension, teacher PD in rural South Africa. By embedding inquiry within culturally grounded practices such as *ingoma* and *ukugida [**Zulu singing and dancing**]* or any cultural activity for that matter, the study demonstrates how IKS can serve as powerful mediating tools for fostering epistemic access, pedagogical creativity, and professional growth. The collective learning process which anchored in Ubuntu philosophy seemed to have redefined practical work not as a procedural or laboratory-bound exercise, but as a relational, embodied, and contextually meaningful experience.

At a conceptual level, these findings challenge the dominant paradigm of science education, which often privileges decontextualised, Western-oriented conceptions of inquiry (Le Grange, 2019; Jegede, 1995). The participating teachers' reflections illustrate that inquiry, when rooted in familiar cultural practices, becomes more than an instructional method, it becomes a way of knowing. The *ingoma [**Zulu singing and dancing***] practical exemplified inquiry cycles (observation, prediction, testing, and explanation) while simultaneously invoking communal participation and embodied understanding. In doing so, it blurred the boundaries between "scientific" and "cultural" knowledge, supporting Ogunniyi's (2007) argument that African epistemologies can mediate scientific reasoning when engaged dialogically. Importantly, the PD that occurred during this process was not externally imposed but emerged organically through collective participation. The teachers' collaborative mapping of IKS-based practicals illustrated what Cochran-Smith and Lytle (2009) describe as inquiry as stance as a disposition where teachers become researchers of their own practice. Through shared dialogue and reflection, teachers co-constructed new understandings of curriculum integration and practical pedagogy that were both scientifically valid and culturally grounded. This aligns with the Ubuntu principle of *"umuntu ngumuntu ngabantu,"* which is the idea that professional growth is relational, sustained through mutual recognition, and achieved collectively rather than individually.

The findings also highlight that meaningful PD must transcend the conventional workshop model that focuses narrowly on procedural skills. Instead, it should create dialogic spaces that legitimise local epistemologies and allow teachers to interrogate their own assumptions about what counts as science. The teachers' "aha moments" during the collaborative mapping exercise illustrate that empowerment arises when PD is both epistemologically inclusive and contextually relevant. As Letseka (2013) argues, Ubuntu-based learning communities cultivate moral and intellectual agency by affirming the interconnectedness of knowledge, and humanity. However, the study also exposes persistent systemic tensions. Teachers' apprehension about assessment and policy alignment reflects the structural rigidity of the CAPS, which leaves limited room for contextualised innovation. This reveals a broader institutional challenge; PD initiatives often prepare teachers to comply rather than to transform. Without explicit policy support, even the most creative and culturally relevant approaches risk marginalisation. This echoes Chisholm's (2019) critique that curriculum reform in South Africa has not sufficiently integrated indigenous epistemologies into the operational structures of teaching and assessment.

This study has several limitations, for example, the findings are based on a small group of rural Life Sciences teachers participating in a context-specific PD initiative and therefore do not claim statistical generalisability. However, the study's purpose was analytical rather than representative, aiming to generate theoretically informed insights into relationally grounded PD. The value of the framework lies in its conceptual transferability rather than direct replication. Practically, the framework offers guidance for universities, subject

advisors, and professional learning communities seeking culturally responsive and sustainable PD models. At a policy level, the study highlights the need to move beyond one-size-fit all PD approaches toward contextually responsive and collaborative teacher development.

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