The Impact Of Integratinga Culturally Responsive Pedagogical Tool In The Teaching Of Deoxyribonucleic Acid In Life Sciences Curriculum

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This study exam ines the impact of a culturally integrative DNA (Deoxyribonucleic acid) lesson plan that merges DNA with Indigenous Knowledge Systems (IKS) related to ancestry, spirituality and ecological relationships. It addresses the need for inclusive Life Sciences education that promote recognition of diverse epistemologies in the classroom. The study is underpinned by the pragmatic paradigm, which values approaches that are responsive to real-world educational contexts. It follows an embedded mixed-methods research design approach, where quantitative data from pre- and post-tests is embedded within a broader qualitative and culturally contextualised framework. The qualitative component includes learners' interviews and storytelling by Indigenous elders, offering culturally rich interpretations of scientific content. Data were collected from thirty Grade 12 Life Sciences learners from a secondary school in Madadeni Township, Hammanskraal, KwaZulu-Natal. The learners were selected through random sampling, while a community elder was purposefully selected for her cultural knowledge and relevance to the study. Learners' results combined test scores (pre-test & post-test) and qualitative reflections to assess both conceptual understanding and cultural resonance. The study draws from a Theory of Ancestral Life Sciences (TALSc.) framework to guide DNA co-pedagogical design, implementation, and empirical evidence. Findings demonstrate improved learner performance, increased ability to compare Indigenous and Eurocentric worldviews, and a heightened sense of belonging and identity. Learners were meaningfully engaged when DNA as contextualised through land-based learning, cultural storytelling and spiritual connections to nature. They demonstrated an improved performance and expressed a deeper sense of belonging. This research supports the development of Life Sciences curricula that incorporate Indigenous Knowledge as co-equal with Western science. It offers an infusion model for culturally responsive teaching in science education and encourages deeper collaboration with knowledge holders in the community. This paper may serve as a blueprint for culturally responsive teaching in other science disciplines.

Key words: *IK pedagogy, TALSc., DNA, ancestry, spirituality, ecology*

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Introduction

Life Sciences education CAPS curriculum is currently facing the hurdle of addressing indigenous knowledge inclusivity and epistemological diversity in classroom settings (Mavuru, 2025). This curriculum tends to privilege Western centred scientific viewpoints, without a room for cultural epistemologies that offer rich heritage to support better understanding understandings of the subject matter (Sonkqayi, 2024). This study bridges this gap by developing a culturally based DNA (Deoxyribonucleic acid) lesson preparation and presentation that connects scientific knowledge of molecular genetics with cultural perspectives on natural environment, ancestry and spirituality relationships.

This study is grounded by the Theory of Ancestral Life Sciences (TALSc.) framework, which emphasizes the value of implementing different epistemologies in the Life Sciences classroom practices (Buthelezi, 2025).The study seeks to

integrate scientific and cultural ways of knowing into the teaching of a DNA content through a collaborative, mixed methodsapproach that involves Western scientists and Indigenous elders. The DNA integrated lesson plan was co-developed with indigenous knowledge keepers and conducted in one of the secondary schools in Madadeni township, Newcastle, in KwaZulu Natal. This provided a contextually grounded intervention that aimed at increasing learner involvement, cultural relevance, and empirical evidence on the relationship between genetics and Indigenous identity.
This collaborative, mixed methods approachpromotes a deep sense of belonging, honour and command respect for learners'cultural practices.In addition, it also promotes learner's' critical thinking ofIndigenous and Eurocentric epistemologies.The study findings advocate for a Life Sciencescurriculum that places the two perspectives as co-equal partners in the Life Sciences content curriculum design and pedagogy. By incorporating storytelling based on ancestry, spirituality and land-based learning with community collaboration, this study offers a model for culturally responsive teaching in Life Sciences as part of the STEM disciplines.

Theoretical Framework

This study is grounded by Theory of Ancestral Life Sciences (TALSc.) theoretical framework. It used a TALSc. approach to design, implement, and refine cultural with scientific worldviews of DNA curriculum unit lesson. The Theory of Ancestral Life Sciences (TALSc.), introduced by Gugulethu, (2025), offers a transformative framework for integrating Indigenous epistemologies into Life Sciences education. Bridging the gap between the scientific and Indigenous epistemologies.
This framework is grounded in three key principles. The first principle asserts that Indigenous Knowledge (IK) is transmitted intergenerationally, that is, within family lineages and through continuous interaction with the natural environment. The second principle highlights the adaptability and flexibility of Indigenous Knowledge, upholding its dynamic nature in response to changing natural environmentalexperiences.The third TALSc. principle is understood to emphasize the interconnectedness of ancestry, spirituality, and natural environment relationships within the Indigenous Knowledge Systems. The adoption of TALSc.third principle by the current studyinspired a development of IK integrated DNAlesson plan that focuses on the ancestryand natural environment tenets. Thisis hoped to demonstrate an increased learner involvement andinculcate a deeper appreciation for the IK epistemologies that contribute to a better understanding of culturally based Life Sciences content.
The TALSc.posits for a pedagogical strategy that values IK as co-equal with Eurocentric scientific ways of knowing, aiming to create a more equitable, inclusive and culturally responsive curriculum.By acknowledging the connections of these constructs, TALSc. seeks to promote a more inclusive and holistic understanding of scientific concepts in Life sciences content, such as DNA.

Literature Review

Indigenous Knowledge Systems and Science Education

Scholars and Life Sciences educators worldwide have recognized limitations of a Curriculum and Assessment Policy Statement (CAPS) that is solely based on Eurocentric ways of knowing (Chuene, 2024). Hence the call of incorporating cultural practices as a co-equal to scientific knowledge has gained momentum. Indigenous Knowledge epistemology offers ancestral, spiritual and natural environment understandings of the content, promoting a holistic approach and relational learning. In addition, according to Silvestru, (2023). It complements the empirical perspectives that dominates scientific methods in Eurocentric epistemologies, which the current study seeks to investigate.
The revised Life Sciences CAPS in South Africa flags the need to integrate diverse epistemologies including indigenous viewpoints of the subject matter.However, its implementation lacks depth and content-specific relevance (Jalilifar & Don, 2024). If the science curriculum is limited to Western scientific ways of knowing and is not accommodative of culturally relevant content, it narrows opportunities for IK to be a co-equal in an educational curriculum. In addition, it limits the inclusion of diversified epistemologies in a curriculum and overshadows learners' indigenous ways of knowing. According to the study integrating indigenous wisdom as an umbrella to ancestry, spirituality and ecology in DNA instruction, can thus serve to both promote a better understanding of DNA scientific concepts and decolonization of the curriculum.

TALSc. Cultural Pedagogies on Ancestry, Spirituality, and Natural Environment

Studies like the one conducted by Buthelezi and Gumbo (2025) has shown that embedding traditional knowledge on spirituality, storytelling and natural environment into Life Sciences enhances learner active involvement. It also promotes a sense of belonging, appreciation of their own heritage andidentity development. Most of the Life Sciences content topics including DNA in genetics are scientific in nature and often taught in scientific terms that are difficult to understand as they don't align to learners lived experiences. However, when these abstract terms are taught within a context of spirituality, ancestral stories and ceremonial cultural epistemologies, learners gain emotional and cognitive domains entry points to Eurocentric ways of knowing, for better understanding of scientific concepts.
In Zulu heritage there are lot of cultural practices that demonstrate interconnectedness with DNA scientific understandings. They are symbolically and culturally linked to DNA to provide ancestral logic about lineage, hereditary identity, and intergenerational continuity. For instance:

The TALSc. first principle of the Teaching and Learning of Life Sciences through culture (TALSc) upholds the intergenerational transfer of Indigenous Knowledge (IK) through family lineages and continuous interaction with the environment. In this context, both Indigenous and Western epistemologies acknowledge that genes carry hereditary information across generations. While Western Science explains heredity as the transmission of genetic material that determines physical traits such as eye colour, height, hair type, and skin tone, Indigenous Knowledge Systems (IKS) extend this understanding beyond biological inheritance. Heredity within IKS embodies a holistic transmission of lived wisdom, encompassing identity (ubunikazi), clan relationships (ubudlelwano bemindeni), community values (amagugu omphakathi), spiritual beliefs (izinkolelo zangokomoya), and harmonious coexistence with the environment (izindlela zokuphilisana nemvelo). These elements are preserved and passed down through ancestral stories, oral traditions, rituals, and ecological practices that sustain the continuity of both knowledge and life. Much like how DNA genetic code material for skin or eye colour is passed down from great grandparents to grandparents, to parents and then to children. Clan praises ***"izithakazelo"*** are traces of family lineage through oral recitation. They are often restated during ceremonies or invoked in moments when seeking strength and clarity from ancestors. Each name cited holds and activate ancestral presence, grounding Life Sciences learners to their roots. The name further demonstrates that identity is not only shaped by DNA but also by spiritual inheritance. These recitations include environmental seasons in which the child was born e.g. if the child was born during rainy season she will be named after the rain "*Nomvula*". In addition, names and victories of our forebears often highlighted their victories, physical traits and behaviours passed down from generation to generation. In DNA (scientifically) these recitations reflect hereditary transmission serving as family trees where family physical characteristics are celebrated in clan names and praises correlate with inherited traits. The naming of Zulu children after ancestors which involves consultation with indigenous knowledge elders. The aim behind this ceremony is for children to carry the essence, behaviour and characteristics of the forefathers (ancestors) to future generations. This ceremony is linked to DNA genetic inheritance linking a child to ancestors. This aligns to the scientific concept that genes carry ancestral traits like height, skin complexion and behaviour etc.

The TALSc. second principle of TALSc emphasises that Indigenous Knowledge is dynamic, adaptable, and flexible mirroring the evolutionary nature of DNA. Just as genetic material evolves through processes such as recombination and mutation, influenced by phenomena like interracial marriages, Indigenous Knowledge also transforms as it encounters new cultural, social, and environmental realities. When different genetic and cultural lineages interweave, they produce new generations that embody blended ancestral traits and evolving identities. This biological and cultural recombination ensures that ancestral wisdom is never lost but instead reconfigures itself in response to changing circumstances. Within this framework, IKS maintains its relevance and resilience, demonstrating that knowledge and identity are living entities that adapt over time while remaining rooted in ancestral foundations.

The third principle of TALSc advocates for relational learning, an approach that bridges Euro-scientific and Indigenous perspectives in understanding DNA and heredity. Learners are encouraged to explore genetics not only through molecular explanations but also through ancestral, environmental, and spiritual dimensions that resonate with their lived experiences. Within Indigenous Knowledge Systems (IKS), paternity may be discerned through the reading of palm lines or symbolic connections between family livestock and a newborn, while Western Science determines biological relationships through DNA analysis of hair, blood, or bone samples. This intersection of knowledge systems creates meaningful teaching opportunities where DNA technology can be understood alongside traditional practices. A profound illustration is seen in the identification and repatriation of ancestral remains, where forensic science confirms lineage and is followed by the ancestral ritual of *ukubuyisa*, the sacred act of returning a spirit home using *isihlahla somlahlankosi*. In this ritual, the spirit of a deceased family member is brought back from the place where body and spirit were separated, such as an accident scene, to the ancestral home. This ceremony reconnects the spirit with the family lineage and invites it to dwell once more among the living, symbolising continuity between generations and reaffirming the invisible ancestral presence within the household. *Ukubuyisa* thus honours the spiritual DNA that binds families together, echoing scientific understandings of hereditary continuity, just as genes link family members across generations in a biological lineage or family tree.

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These TALSc. constructs align with cultural pedagogies that aim to flag for learners' heritage of diverse learners co-existing with scientific epistemology while promoting academic progress.Ancestral logic about lineage, hereditary identity, and intergenerational continuity closely alignswith the constructs that underpin the Theory of Ancestral Life Sciences (TALSc.). Integrating indigenous perspectives in DNA teaching under these tenets is not merely biological, but promotes relational learning, ancestry, spiritually and ecologically alignment.

Culturally Responsive Curriculum Co-designing with Indigenous Communities

Designing authentic IK integrated lesson plans in Life Sciences according to the study, requires an active involvement of educators with indigenous community elders and knowledge keepers. Co-designing ensures that the knowledge is contextually accurate, not misrepresented, not disrespected and the strategy is culturally sensitive. The TALSc. participatory research method is aligned with Indigenous research methodologies, that upholds relational accountability and respect for learners' cultural traditions. The proposed collaborative mixed methods that ground the study builds on this notion, demonstrating IK integrated curriculum pedagogical benefits.

The Theory of Ancestral Life Sciences (TALSc.) as proposed by Gugulethu, (2025), contributes to a growing body of work advocating for transformative Life Sciences education curriculum that is culturally inclusive of Indigenous epistemologies. The theory supports the idea that Eurocentric and Indigenous epistemologies are not to be viewed as oppositional, but as equals that can be co-equally represented in the Life Sciences classroom.TALSc. provides a culturally oriented theoretical and practical framework that upholds learner involvement in Life Sciences teaching, aligning with global efforts to integrate IK while promotinglearners' emotional and cognitive justice.

Although studies based on the diverse epistemologies e.g. integration of IK in Life Sciences classroom teaching, have gained its momentum(Sitsha, 2023), a little is known on the practical implementation of the strategy in the classrooms. And thus, a gap in empirical studies that measure an impact of IK incorporated lessons in Life Sciences especially in the alignment of topics like DNA heredity, ecology, ancestry and spirituality. The most recent literature mainly focuses on philosophical frameworks, curriculum policies that may not necessarily provide classroom-based empirical data that evaluates how IK integration strategies promote learner involvement, learners' sense of belonging, DNA conceptual understanding and critical comparison of the two epistemologies regarding DNA.

This study addresses this critical empirical gap by co-designing a DNA lesson with local elders and keepers, implementing it in a classroom setting, and evaluating learner participants. It employs a mixed methods approach to generate empirical evidence on the pedagogical, cognitive, and cultural impacts of teaching DNA through a culturally integrative framework grounded in the TALSc. The findings aim to inform curriculum development, teacher practices, and policy reforms that promote epistemic inclusivity in STEM education.

Methodology

This study used a mixed methodological approach that is aligned with theTALSc.framework (Gugulethu, 2025) to co-design, implement, and refine a culturally based DNA curriculum unit. It emphasized collaboration of educators with indigenous knowledge holders and elders in the co-planning of IK integrated lesson plans.

Context and Participants

This empirical study was carried out with the contribution of indigenous knowledge elders and a qualified subject educator. The study wasconducted in a Grade 12Life Sciences classroom settings at one of the public secondary schools in Newcastle, Madadeni township. The class included 25 Zulu speakinglearners,whom 40 % identified themselves as originating from Hamanskraal and Blaauboschrural communities. Twolocal Indigenous elders advised on the cultural part of DNA content, while one Life Sciences teacher advised on the CAPS curriculum or scientific part of DNA content and pedagogy.

Data Collection

Data sources included a quantitative component with pre- and post-tests, as well as an intervention approach in the form of a culturally oriented lesson plan presentation that is organized into three objectives for DNA instruction: *scientific, indigenous, and integrative lesson objectives*. A Life Sciences instructor scaffolded the third scientific aim and involved direct teaching methods, use of visuals and demonstrations of a scientific aspect of DNA, as required by the CAPS curriculum. The indigenous knowledge objective was executed with the active participation of two Indigenous community elders in learner activities. The integration objective included both learners and educators comparing and critically discussing how *ukubuyisa, izithakazelo nokwetha amagama* links to scientific DNA heredity.Learners' test scores were compared to determine the impact of the instructional technique.

Quantitative

TALSc. Intervention Strategy: Indigenous Pedagogy

Below is a practical, IK Life-sciences-aligned DNA classroom lesson presentation. Thislesson is designed to align with Life Sciences scientific, Indigenous Knowledge and integration learning outcomes. The lesson sample enable Life Science educators to deliver inclusive DNA curriculum content while embedding its link to spirituality, ancestry and land-connection pedagogy. Each lesson objective fosters deeper engagement, cross-cultural understanding, and critical ecological literacy.

LESSON PLAN:DNA and heredity
GRADE: 12
SUBJECT: Life Sciences
DURATION:120 minutes

TOPIC:IK integrated DNA Instruction through the Lens of Ancestry and Natural Environment		
At the end of this lesson, learners should be able to:		
SCIENTIFIC OBJECTIVE Describe the basic structure of the DNA molecule (e.g., double helix, base pairs). Define and differentiate between genes, chromosomes, and DNA. Explain the DNA replication, protein synthesis during cell division.	**IK OBJECTIVE** 1. Explain the symbolic use of trees likeumlahlankosi" in Zulurituals. 2. The use of "impepho" for ancestral consultation and spiritual protection. 3. Link environmental elemente.g. tree toancestral continuity. 4. Storytelling on paternity testing.	**INTEGRATED OBJECTIVE** Explore the molecular structure and function of DNAfocusing on its role in genetic inheritance, DNA replication, and protein synthesis, while drawing connections to how Indigenous Knowledge such as the symbolic use of sacred trees like "umlahlankosi" in Zulu rituals represent ancestral presence and environmental interconnectedness.
Learning and Teaching Support Material (LTSM)		
1. DNA structure posters/models 2. Flashcards with terms: DNA, genes, chromosomes, etc. 3. Animated videos/simulations on DNA replication and protein synthesis	Audio or video narration / Indigenous elder doing a storytelling onukubuyisa and paternity testing OR Role-playing a mock crime scene of ukubuyisa.and the use of "impepho" for ancestral consultation and spiritual protection.	Storytelling materials, video recordings, or visuals of traditional Zulu rituals involving"umlahlankosi"and the use of "impepho" for ancestral consultation and spiritual protection.
Teaching Strategies:		
Teacher-Centred Learner Centred	Learner Centred	Learner Centred
Teaching Methods:		

Direct instruction (chalkboard + visuals) Game-based learning (e.g., flashcard challenges)	**Interactive simulation, roleplaying and storytelling led bya community elder.**	**Co-operative Learning ..... Group learners into diverse teams to research, compare and present scientific and Indigenous perspectives on DNA.**

LESSON PRESENTATION:

Teacher speaks to learners:
"Have you ever wondered what makes you *you*? Why do you have your mother's eyes or your father's dimples? The a powerful, DNA. DNA tells your body how to grow, how to look, and even how to function.
Today, we're going to explore the basics of DNA, what it is, where it lives inside your cells, and how it works like a recipe to there. We'll also apply what we learn to real-world situations.Let's start by watching a short animation that shows how new this is where DNA first comes together."
(Play short animation on fertilization and DNA)
After the video:
In Zulu tradition, the branch of a tree, "*igatsha lesihlahla somlahlankosi*",is used to pick the spirit of someone who passed aw and the use of "impepho" for ancestral consultation and spiritual protection when bringing their presence home again. S involves DNA, Indigenous Knowledge helps us understand why life is special. Together, they help us learn about ourselves, fro
Spiritually, that's reconnecting them with the family.
Biologically, we'd say their DNA lives on in the family line. Two ways of seeing the same truth.
Let's explore how *science and Indigenous Knowledge*come together to help us understand who we are."

LESSON OBJECTIVES	TEACHER ACTIVITIES	LEARNER ACTIVITIES
SCIENTIFIC OBJECTIVE	**Use visual aids (e.g. diagrams, models, posters) to teach DNA structure and location.** **Use flashcards with terms: DNA, genes, chromosomes, etc.** **Play animated videos/simulations on DNA replication and protein synthesis**	**Engage with visual representations such as DNA models, labelled diagrams, and cell charts to observe and describe the structure and location of DNA within the cell.** **Participate in matching terms with definitions (e.g., gene, chromosome, nucleus), solving science-themed crossword puzzles, and using flashcards to reinforce conceptual understanding** **Observe and complete a guided worksheet to sequence the steps of DNA replication and protein synthesis as shown in the simulation.**
INDIGENOUS KNOWLEDGE OBJECTIVE	**"Storytelling - Ukubuyisa"** **What to Teach:** **Teach learners about a Zulu ritual (*ukubuyisa*) that uses a special, symbolic branch called *isihlahla somlahlankosi* to welcome back the spirit of an ancestor.** **Play a short video of *ukubuyisa* ritual. This builds respect for indigenous knowledge and enhances understanding of inheritance.**	**Isihlahla somlahlankosi and DNA.** **FOCUS AREA:*Ancestry + Natural Environment*** **In groups, learners simulate a respectful version of an *ukubuyisa* ritual using safe classroom props (e.g., a symbolic "branch" as *isihlahla somlahlankosi*).** **Afterward, they discuss and write "What does the ritual represent?"** **In class, learners discuss how the**

			tree/branch is used to represent the return of spirit and family connection, like genes passed down biologically.
	INTEGRATION OBJECTIVE	**Facilitate group work comparing Indigenous oral histories with DNA-based ancestry tools using a Venn diagram.** **Host a structured debate on the pros and cons of DNA testing (ethics in health and ancestry).**	**Comparing Indigenous oral histories with DNA-based ancestry tools using a Venn diagram in groups.** **Debate on the pros and cons of DNA testing (ethics in health and ancestry).**

Summary

Learners explore the structure and function of DNA and its role in heredity, DNA Replication and protein synthesis. This sc Indigenous Knowledge, focusing on the symbolic role of sacred trees like umlahlankosi in Zulu rituals as representatio connection to the environment. The lesson promotes holistic learning by linking biological inheritance with cultural, spiritual,

ASSESSMENT:

SCIENTIFIC OBJECTIVES	INDIGENOUS KNOWLEDGE	INTEGRATION OBJECTIVE
Remembering: Describe the structure of a DNA molecule.Define genes, chromosomes, and how they relate to DNA. **Understanding: Explain how DNA is replicated during cell division.** **Applying:How can DNA evidence be used in solving real-world problems, such as in criminal investigations?**	**Project-based Assessment, Visual and Oral Presentation, Class Discussion,** **Oral Presentation,** **Trait Identification Sheet**	**Presentations and Dialogue:Each group compares Indigenous and scientific perspectives on:** • **Ukubuyisa: How does the Zulu practice of bringing back ancestral spirits.** • **Relate to how DNA links us to our ancestors?**

Data Collection

The study used a mixed-methods approach grounded in TALSc., to evaluate the impact of integrating Indigenous Knowledge into DNA teaching. Qualitative insights were gathered through classroom observations and contributions from Indigenous elders, which highlighted student engagement and cultural connections. Quantitative data from pre- and post-assessments measured learners' improvement in understanding DNA ancestry, spirituality and natural environment. Learner reflections added a personal dimension, revealing increased appreciation for their heritage and identity.

Presenting Quantitative evidenceand Interpretation

The study employed a **diverse set of data sources and tools** to ensure a well-rounded evaluation of the impact of integrating Indigenous knowledge with DNA instruction in Life Sciences. P*re- and post-lesson assessments*were used to generate **quantitative evidence** of knowledge improvement. These included both multiple-choice and open-ended questions to assess learners' conceptual understanding of DNA and its connection to heritage and ancestry. *Learner feedback*, gathered through surveys and reflections, provided a **mixed-methods perspective**, combining numerical data (e.g., scores) with qualitative responses (e.g., emotional and cultural identity).

Comparing Learners' Performance on pre and post-tests

Below are the tables and bar graph showing the pre-test scores, post-test scores, and improvement across various indicators related to learners' understanding of DNA through both Eurocentric and Indigenous lenses. Let me know if you'd like this visual styled further or incorporated into a report.

Table 1: Standard Deviations of Pre-test, Post-test, and Improvement Scores

Category	Standard Deviation (SD)	Interpretation
Pre-test scores	5.31	Greater variation in learners' prior knowledge
Post-test scores	3.21	More consistent performance across learning indicators
Improvement scores	4.93	Suggest a relatively uniform gain in performance

These standard deviations illustrate the spread of scores around the mean, showing how learner performance became more consistent after instruction.

Table 2: Indicators of pre- and post-tests scores and improvement

Indicators	Pre-test scores	Post-test scores	Improvement
Understanding DNA structure and functions	**52%**	**84%**	**+32%**
Connecting DNA to ancestry	**46%**	**89%**	**+43%**
Connecting DNA to spirituality	**42%**	**86%**	**+44%**
Connecting DNA to natural environment	**40%**	**81%**	**+41%**
Critically comparing Eurocentric and Indigenous perspectives on DNA	**39%**	**82%**	**+43%**

Figure 1: Bar graph of pre-test, post-test scores and improvement across indicators

Learners' scores indicated a moderate performance in the pre-test, suggesting a partial prior knowledge on concepts related to DNA.These scores served as a baseline entrance for intervention process.However,after an intervention strategy, a significant improvement in the understanding and practical application of cultural traditionsin DNA-related topicswas observed. This suggested a positive impact on learners' cognitive,emotional and relational dimensions of the DNA lesson.

Descriptive statistics (mean averages, percentages, standard deviations and gain scores) were used (Ghanad, 2023) to compare pre- & post-test averages, determine learning gains and measure extent of improvement in learners' performance following the intervention (post-test). Descriptive Analysis demonstrated learners' progress and provided evidence of the effectiveness of a teaching strategy.

Presenting Qualitative evidence and Interpretation

*Classroom observations*provided qualitative insight through checklists and field notes while interacting with Indigenous elders, allowing a researcher to capture the real-time engagement, participation, and shifts in learner behavior. This method revealed not just what learners knew, but how they interacted with culturally enriched content, making it particularly valuable for understanding the emotional and relational dimensions of the DNA lesson. Observing non-verbal cues, group dynamics, and classroom atmosphere helped me triangulate the learning process beyond test scores. Additionally,*elder contributions*, documented via interviews and storytelling, brought a deeply**qualitative and community-grounded viewpoint**to the data, reinforcing the legitimacy of Indigenous epistemologies in Life Sciences formal education. These multiple tools and methods enriched the study's validity and allowed for a more culturally responsive analysis.

1. **Heritage Connection and Active Learner Involvement**

Table 2: Heritage Connection and Active Learner Involvement

DNA Learning Aspect	Researchers' Observations	Frequencies in %
Participation in class discussions in IK and integration objectives.	**High**	**70%**
Participation with Indigenous elders and knowledge keepers.	**High**	**74%**
Participation referring to learners' own DNA family heritage.	**High**	**75%**
Participation in asking culturally informed DNA questions during discussions.	**Moderate**	**60%**

Figure 3: Bar graph of Researchers' Observations on DNA Learning Aspects

L5: *"I didn't know that DNA could connect with our family history and ancestors. Now it makes more sense to me why my sister has albinism. Our great-grandmother transferred this genefrom her generation to our 4th generation."*
L12:*"Life Sciences used to feel far away from me and my modern life. Our grandfather used to guide our deceased family members from hospital beds to mortuaries- home then to final resting place while murmuring, using a symbolic tree"**isihlahla somlahlankosi**". After thislesson, I could see how my grandfather's wisdom fits into Life Sciences."*
L3:*"My father always shared family stories like preparing medicinal plants and family tree.* ***ukuhloma abafana egcekeni*** *to prevent lightning from striking human dwellings,not standing under the tree when there is lightningor how they dig soilto store food, preventing decay.But I never thought of them as science until now."*
L25:*"I used to think DNA was just about a content in Life Sciencestextbooks. But after this lesson, I came to realize that it's also in our family names and how we look physically."*
L16:*"I didn't know about* ***isihlahla somlahlankosi*** *before. I once sawmy elders at home talking to a tree branchfromhospital beds or accident scenes, via the mortuarywhere a deceased was kept before burial but had no recollection of what was used for. Hearing whyit is used and the purpose behind it helped me connect our culture withgenetic continuity."*
L7:*"I've never enjoyed Life Sciences much. I am into numbers, I love maths and physics, but this intervention was a game changer, it was different. This lesson helped me understand that my physical appearance and personality were carried through my family and ancestral lineages. Thecharacter that people see and admire in me,has been carried through my family and ancestral lineages"*
L21:*"We are shaped not only by the DNA in our bodies, but we also inherit our ancestral stories, traditions and values that guide our traditions, that gives us a sense of belonging and the values passed down through generations. Ancestral wisdom, spirituality, language, and environment all play vital roles in forming who we are."*
L9:*"Combining scientific DNA with our cultural knowledge made the topic personal to each an everyone of us. It made me honour the people who came before me, people who risked their lives using their bodies as laboratories to test medicinal plants for future generations. It honestly made methink about who I am and where I come from."*
L10: *"Now I realise Life Sciences and tradition don't have to be separated, they should be taught together in class. Both can helpto explain each other."*

2. Evidence of Integrating Local Knowledge to Western science

Collaboration with the two Indigenous Elders from the community co-facilitated storytelling about *symbolic* trees, and spiritual beliefs like *ukubuyisa*. The use of local materials like medicinal plants used for spiritual protection "*impepho*" which were eventually linked to biological properties like DNA. These plants were picked following their DNA properties like structure, shapes, colour and odour as compared to their ancestral plants. Learners were also involved in land-based learning where activities like tracing the whereabouts of a symbolic tree of *isihlahlasomlahlankosi* tree were conducted in indigenous places. This evidence helped learners connect to their heritage under the ancestry, spirituality, genetic identity and natural environment TALSc. tenets.

3. Observations and Reflection Thematic Insights

Below is a structuredSaldana coding system that moves from codes tocategories, and the distil themes and sub-themes that guided aqualitative data analysis, such as coding interview transcripts for Indigenous eldersand learner reflections.The categories served to create rubrics for assessing changes in learners' behaviour, participation and perceptions. These align with TALSc., a transformative learning theoretical framework and culturally responsive IK integrated Life sciences pedagogy.

Table 3: A Saldana Coding System Framework: Codes, Categories, Themes and sub-themes

Categories	Themes	Sub-Themes	Description
A sense of belonging	**Cultural Identity &Learners' Personal Connection to heritage**	**1. Recognition of ancestral roots 2. Affirmation of identity through DNA and clan names**	**Learners began to see Life Sciences as a reflection of their own lives and heritage, strengthening their connection to both family and education curriculum.**
Critical Comparison	**Two Epistemologies Dialogue**	**3. Respectful critique of Western science 4. Validation of Indigenous knowledge**	**Students learned to hold both Westernized and Indigenous perspectives side-by-side, engaging in thoughtful comparison without privileging or marginalizing IK over the Western views.**
Intergenerational Respect	**Family Knowledge Transmission**	**5. Valuing oral traditions 6. Elders as knowledge holders**	**Learners acknowledged the role of Indigenous elders and saw their teachings as essential contributions to Life Sciences learning, similar in importance to their subject textbook content.**
Ecological/Natural	**Nature-Spiritual-**	**7. Viewing plants as**	**Students began to connect natural**

environment Awareness	**Biological Connection**	**spiritual and biological tools 8. Rituals as ecological practices**	**elements like herbs and trees with both scientific function and cultural significance.**

LEARNERS PARTICIPATION on indicators:

Learner	Class Discussion on IK & Integration Objectives	Participation with Indigenous Elders	References to DNA & Family Heritage	Culturally Informed DNA Questions	Total Participation
L1	4	2	3	1	10
L2	2	1	1	0	4
L3	5	3	2	2	12

CALCULATION FOR FREQUENCIES ON EACH INDICATOR (Learner participation):

Raw frequency: Tally /count each time a learner participates. Finally, sum up totals for each learner.
For instance, Learner 1 = 10 contributions, Learner 2 = 5 contributions.
Then calculate frequencies and percentages.

Relative frequency (%): Divide each learner's contributions by the total group contributions.

$$\textbf{Relative } \textit{frequency (\%)} = \frac{\textit{Learner's contributions}}{\textit{Total contributions}} \times 100$$

LEARNERS INTERVIEWS:

From Saldaña, J. (2024) thematic analysis, the researcher adapted a coding tree for the current study that systematically linked

Evidence → Sources → Theme → Subthemes while aligning this with TALSc. Principles.

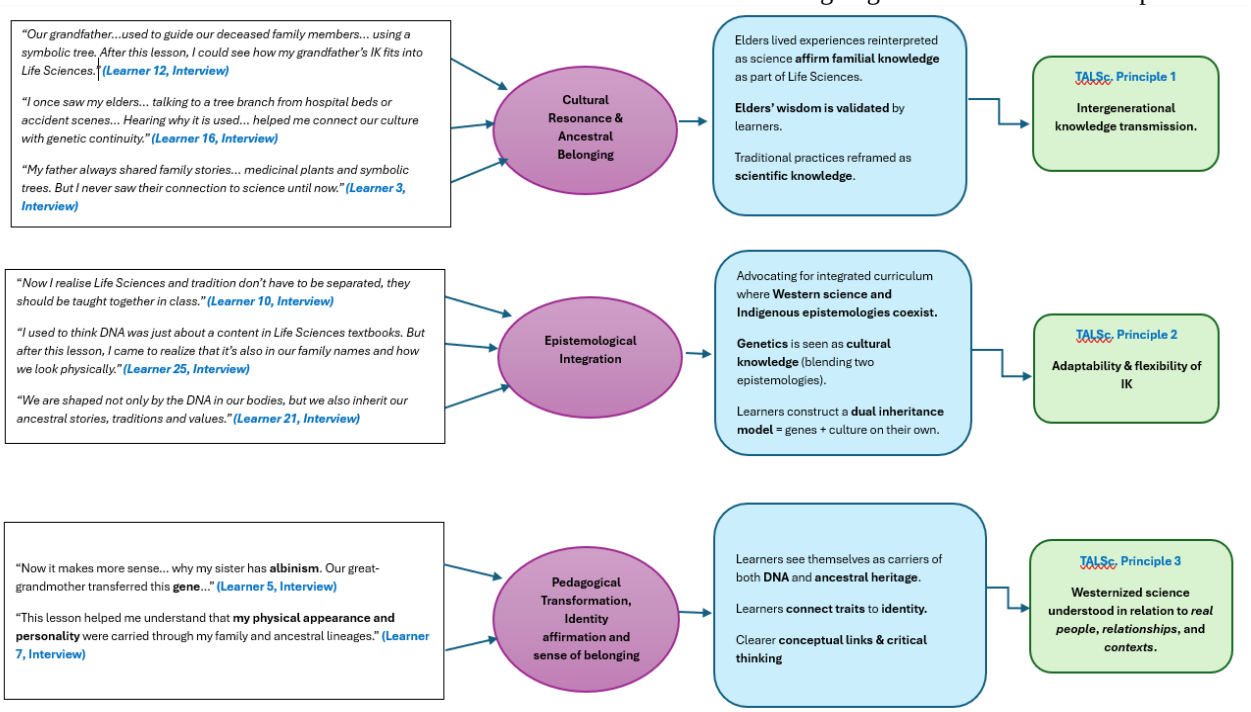

Figure 1:A study coding tree

Analysis and Discussion of Findings

Learners began to understand DNA as more than just a content topic found in Life Sciences textbooks. They saw a science concept shaped by ecology, ancestry, culture, spiritual ties. While DNA helped explain traits passed from parents to childrenJiang et.al., (2024), many learners also recognized the importance of family stories, traditions, and a sense of belonging. For Indigenous learners, this approach felt personal and respectful. They felt more included in a Life Sciences class, and many spoke with pride about their family roots during mapping and storytelling activities.

Bringing Indigenous and scientific knowledge together in the classroom helped students see Life Sciences in a new perspective. It wasn't just about scientific facts and definitions, it became about relationships, responsibility, and understanding where we come from, our roots. This shift moved science learning beyond memorizing content, toward making meaningful connections, promoting relational learning. These results support what other researchers, like

McNeill et.al., (2025) and Tripon (2024), have said: that science education should include the voices, values, and experiences of the learners it serves.
Learners' scores indicated a moderate performance in the pre-test, suggesting a partial prior knowledge on concepts related to DNA. These scores served as a baseline entrance for intervention process. However, after an intervention strategy, a significant improvement in the understanding and practical application of cultural traditions in DNA-related topics was observed. This suggested a positive impact on learners' cognitive,emotional and relational dimensions of the DNA lesson.

Description of Learning Outcomes
Learners showed noticeable improvement in their understanding of DNA and genetics following the lesson intervention. Their ability to explain scientific concepts, such as how DNA carries inherited traits and how it replicates during cell division, was markedly stronger. Many learners used scientific terms more accurately and confidently in discussions and written work. These gains suggest that integrating cultural themes into the science curriculum did not compromise academic content. Instead, the approach deepened interest and made the material more accessible by connecting it to the learners' own contexts and backgrounds.
The incorporation of Indigenous knowledge significantly increased learners' engagement, particularly when content touched on familiar cultural practices like *ukubuyisa*and burning of *impepho* for spiritual cleansing. This aspect of the lesson helped learners feel seen and validated. They connected more deeply with the subject matter because it reflected their families' stories, rituals, and values. Many expressed that science felt "less distant" when explained through lenses they recognized. This cultural alignment helped transform the classroom into a space of mutual respect and learning.
One of the more subtle but powerful impacts was the development of critical reflection. Learners began to question how knowledge is formed, comparing textbook science with Indigenous wisdom passed through generations. They didn't discard one view for the other; instead, they explored how both perspectives might coexist. This kind of critical engagement allowed students to move beyond memorization. They began to reflect on the limitations and strengths of different worldviews, which is a key marker of intellectual maturity in science education.
The lessons also had a meaningful effect on how learners viewed themselves. Through creative tasks, like building symbolic family trees, students were invited to reflect on who they are, where they come from, and how that connects to their biology. This process sparked conversations abouttraits, ancestors, and cultural pride. Learners saw that their heritage had a place in the science classroom, which encouraged confidence and belonging. For many, science no longer felt like something "external" to their lives but became something they could relate to personally.

Conclusion
This study demonstrates the pedagogical value of a culturally integrated Life Sciences lesson on DNA. It grounded genetics education in both molecular science and Indigenous Knowledge to fostercultural connection, ethical reflection and learner involvement engagement. TALSc. framework proved instrumental in equally bridging two diverse epistemologiesin a science classroom without privileging the other.This study shows that integrating Indigenous knowledge into DNA education can enhance learners cognitively, while also validating scientific and Indigenous knowledge ways of learning. Indigenous knowledge enriches Western scientific views by adding relational, ethical, and spiritual dimensions rather than replacing it. This aligns with calls for decolonizing STEM education both in schools and in Higher education institutions.
The success of this lesson plan suggests that culturally integrative approaches are not only pedagogically sound but essential. Learners learned not just how DNA works scientifically, but howcultural identity is storied, lived, and embedded in the community.

Findings
The findings highlight that teachers who wish to design integrated lessons should start by establishing authentic, respectful relationships with Indigenous knowledge holders. These partnerships must move beyond surface-level consultation and allow Indigenous voices to genuinely shape both the curriculum content and its delivery. Embedding learning in the land and using storytelling as a teaching approach further strengthens this integration, as these methods connect scientific ideas to the lived experiences, histories, and identities of learners and their communities.
Equally important is creating open, respectful dialogue around ethics, particularly when working with culturally sensitive knowledge or questions of data ownership. Such ethical awareness ensures that the process remains grounded in care and integrity.
When these culturally grounded practicessuch as land-based learning, storytelling, and acknowledging ancestry and spiritual connections, are applied thoughtfully, they not only honour both scientific and Indigenous ways of knowing but also transform the science classroom into a space of inclusion and respect.
Quantitative findings revealed that these approaches significantly improved learner performance in DNA concepts, leading to:

- Deeper conceptual understanding
- Clearer conceptual linkages

- Movement beyond rote memorization of content

Qualitative findings indicated that learners showed deeper engagement with both epistemologies, which fostered:

- Enhanced critical thinking
- Stronger cultural connectedness
- Sustained interest in learning
- A deeper sense of belonging and identity within science education

The integration of Indigenous and Western scientific perspectives cultivates a richer, more meaningful learning experience, one that values knowledge diversity and strengthens learners' connections to both science and culture.

Recommendations

The findings highlight the need for a culturally integrated and transformative pedagogy in Life Sciences education. They advocate for the legitimized inclusion of Indigenous Knowledge Systems (IKS) as co-equal to Western science, encouraging collaboration and co-teaching with Indigenous Knowledge keepers. The study further proposes the infusion of the TALSc model as a framework for culturally responsive teaching that values both experiential and scientific ways of knowing. Such an approach supports storytelling, learner engagement, and the blending of lived experiences with scientific inquiry, ultimately fostering a holistic and inclusive learning environment.

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