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Exploring the Integration of Indigenous Knowledge into Life Sciences Pedagogy in the FET Phase

Buthelezi Penelope Zamashenge Gugulethu[1], Mishack T Gumbo[2]

[1]University of Zululand, South Africa; ButheleziP@unizulu.ac.za
[2]University of South Africa; gumbomt@unisa.ac.za

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Abstract. This study investigates the pedagogical integration of Indigenous Knowledge (IK) into enzyme education within the Further Education and Training (FET) Life Sciences curriculum in Kwa-Dlangezwa, KwaZulu-Natal. Recognizing the marginalization of Indigenous epistemologies in formal science education, the research aims to bridge the disconnect between learners' cultural knowledge and school-based scientific content. Employing a qualitative ethnographic design informed by Cultural-Historical Activity Theory (CHAT), the study engaged community knowledge holders, educators, and learners through interviews, classroom observations, and participatory lesson design. Findings indicate that incorporating local enzymatic practices, such as beer fermentation in traditional food preparation enhances conceptual understanding, learner engagement, and cultural relevance. The study contributes to current discourse on decolonizing science education by providing a practical framework for aligning IK with curriculum objectives. It underscores the cognitive and affective benefits of contextualized teaching and positions IK not as supplementary but as integral to robust scientific inquiry. The findings advocate for inclusive pedagogical models that legitimize diverse ways of knowing in the Life Sciences classroom.

1. INTRODUCTION

The research investigates the impact of incorporating Indigenous Knowledge (IK) in Life Sciences education on Grade 10 students' understanding of enzymes, revealing that Indigenous knowledge is often overlooked in the classroom (Mkhwebane 2024). Indigenous knowledge systems-based wisdom has been passed down from one generation to the other by several ethnic groups and it is their collective experience. response Some of the arranged material in the CAPS Life Sciences curriculum in South Africa is comparable to arrangements and subject-matter of the SCQF International Programmes, though it may be recognized that they differ (Department of Basic Education, 2011; Scottish Qualifications Authority, 2020). Scottish Qualifications Authority, 2020). The study explores the application of Indigenous Knowledge (IK) in Grade 10 Life Science classes on enzymes, aiming to bridge the gap between students' cultural backgrounds and traditional science education. It aims to create a learning environment that integrates scientific teaching with cultural practices, focusing on environmental protection and social responsibility. The study aims to determine the degree of indigenous knowledge application and its benefits for learners.

This study evaluates the effectiveness of Interactive and Kinetics (IK) in science education, focusing on action-oriented approaches like simulated role-plays, virtual classrooms, and community collaboration. It highlights the need for more inclusive and culturally responsive teaching methods in Life Sciences curricula, highlighting the importance of understanding enzymes through IK.

2. THEORETICAL FRAMEWORK

Theoretical basis of this research is Lev Vygotsky's Theory of Cultural-Historical Activity. CHAT explores the connection between learners' educational experiences and the wider social, cultural and historical contexts. In this study, CHAT highlights the importance of learners' cultural heritage and collectivist activities in the formation of the Life Sciences teaching environment. CHAT helps understand and acquire collective behaviours of a society (with rituals and practices) and its communicative resources (language, symbols, and artifacts). This theoretical perspective helps disclose the influence of culture on individual behaviour and the forms of educational practices. According to the CHAT principles, we reviewed current literature on enzymes and IK education in CAPS for the 10th Grade Life Sciences. Using information from diverse sources we were able to raise attention to areas where CAPS do not have explicit indications on the manner of integrating IK.

3. LITERATURE REVIEW

CAPS recognizes the significance of Indigenous Knowledge Systems, although its implementation in the Life Sciences academic program is constrained. Doing this requires comprehensive teacher training, policy guidelines that are clear and an adequate resource. Quantum to acceptance of digital tools/literature together with ethics considerations, the calibration of IKS can be supported further by which will make the learning experience extended, culturally enhanced for the South African ones.

3.1. The Integration of IK in Life Sciences CAPS Curriculum

Adoption of Indigenous Knowledge Systems (IKS) into science classroom practice in South Africa has recently attracted much focus. Although Life sciences CAPS curriculum admits to the importance of IKS. Specific aim 3 of the Life Science CAPS curriculum aims at developing learners' understanding and appreciation of the nature, history and practice of science. It motivates

*Corresponding author.

the learners to go into the construction of scientific knowledge based on observation experimentation and critical thinking, considering the ethical consequence of scientific advances. The aim facilitates the emergence of aware citizens who are also capable of being interested in society. However, the actual implementation is still not clear as it shows various challenges and opportunities (Department of Basic Education, 2011).

3.2. Reviewed Gaps in CAPS as it Relates IKS Integration in Life Sciences

CAPS for Life Sciences focuses on literacy in science and practical contexts. Despite attempts at promoting the IKS use, school curriculums generally fail to provide specific information which leads to patchy or weak integration of the IKS across institutions. Knowing that in his search, Mkhwebane (2024) found out that teachers understood IK, but their expertise on IK exclusively from textbooks, without practical skills, constrained its integration in Life Sciences topics such as cellular respiration, animal tissues, the biosphere, biodiversity, and human nutrition. This means that the teachers lack sufficient pedagogical skills to use IK in Life Sciences topics from grades 10-12, thus the use in the classroom is limited. Sefoka & Chuene (2025) in their research noted that the blending of IK in science classes in boosted learner interest in science classes, and life science concepts became more accessible, giving reasons for specialized professional development programs in universities and workshops. The CAPS curriculum incorporates Indigenous Knowledge Systems (IKS), which does however fall short, as it does not provide intensive training for future or current teachers, or even meaningful professional development.

3.3. Teacher Preparedness and Resource Constraints

One of the challenges to the use of Indigenous Knowledges Systems (IKS) in the life sciences curriculum is rooted in the enduring readiness gap among teachers, institutional infrastructure, as well as available resources. Policy statements that endorse IKS, including CAPS, evidence its importance, but its practical application is a mirage due to constant limitations in teacher training. Selective analysis of the work of Selepe et.al. (2022) undertaken in KwaZulu-Natal shows that educators commonly perceive the integration of IKS into the science education sector positively and perceive this as relevant to the learners' cultural backgrounds; however, they are not always ready to make it effective. It was clear from the work by Selepe et al. (2022) that teachers could not afford to depend on appropriate pedagogical tools or materials which were in line with the curriculum to confidently incorporate IKS into core science instruction. This is further aggravated by an inconsistent interpretation of policy at school level. In keeping with this concern, De Bruin (2024) argues that the current status quo in IKS education in South Africa is hindered by lack of formal training and clear curricular directions for teaching professionals. This lack of development, community partnerships, and curriculum reform is crucial for establishing an inclusive and contextually relevant education system.

3.4. Policy Initiatives and Recommendations

The Department of Basic Education is implementing initiatives to integrate Indigenous Knowledge Systems (IKS) into the curriculum, including more resources, training programs, and culturally respectful approaches. These include incorporating indigenous examples in science and life sciences, involving local elders, and using cultural stories to increase learner engagement.

However, promising these initiatives are not brought to an optimal level nor does it come without a whole lot of challenges. According to a researcher Molise (2025) educators are still facing great obstacles such as time constraints attributed to already overstuffed curriculum and lack of IKS in standardized format across subjects and lack of institutional support. A lot of teachers also comment on the issues of how to objectively and efficiently measure IKS know-how during the CAPS curriculum assessment. Consequently, according to Cindi (2021) despite policy and pilot initiatives indicative of growing understanding of the role IKS play, the gap between desire and actual classroom utilization is an important problem that needs support, local curriculum development, global communities-school links, and reinforcement.

3.5. How Digital Tools are Helpful in the Long-Term Care of IKS

The digital revolution creates a revolutionary opportunity to document, archive, and preserve Indigenous Knowledge systems (IKS), particularly in settings where the traditional oral tales and culture may be lost as generation dynamics change and as modernization derails traditional communication. Chigwada and Ngulube (2024) have drawn attention to the fact that digital tools, such as online repositories, cell phone applications, and multimedia archives provide spectacular means of capitalizing on, and sharing indigenous knowledge with educators, researchers, and younger people. Such innovations can outwardly present and legitimate Indigenous Knowledge Systems in such a way as to be more obtainable within the mainstream educational system such as CAPS.

However, the process of digitization is characterized by high challenges. Address of the ethically managing the Indigenous knowledge has also been one of the major concerns, which have been first related to the problem with data ownership, intellectual property rights, as well the necessity to get the implied consent of the knowledge holders. Chigwada and Ngulube (2024) warn that unless strong implementation of ethical protocols occurs, digital effort to capture IKS may have unknowingly commodified or distorted IKS by stripping it of its cultural background and context. In addition, there are many Indigenous populations who still wanted to be careful of outside agents attempting to "extract" their knowledge for academic/commercial use with the benefits fairly paid out and the knowledge properly accredited. Thus, any attempt at digital preservation should have as a foundation community led decision making, processes of consent that are transparent, and considerations of custodianship and the spiritual value of the Indigenous knowledge.

3.6. Enzymes as the Critical Component of the knowledge of Life Sciences in the Scope of IK

IK, as described by Hadlos et.al., (2022), is the total wisdom and habits of native and indigenous groups closely connected with their natural world. This covers traditional methods of food preparation and local herbs application for medical purposes. This is visible in the actual demonstration of fermentation processes in drink brewing (the temperature used for enzyme activity here is room temperature, and the contents of the bottle or jug ferment), such as African beer (umqombothi). Zulu culture Indigenous Knowledge in Life Sciences includes an intimate knowledge of natural processes with numerous elements based on enzyme processes that may not always be scientific but has other ways to express it.

3.6.1. Traditional Beer Brewing (Umqombothi)

Umqombothi is a traditional beer made from malt, maize, and water, containing amylase enzyme synthesis. The grains are soaked in lukewarm water, and yeast is added for fermentation, producing a refreshing alcoholic beverage. Globally, umqombothi has religious, ceremonial, and social importance to the Zulu people. The art of brewing is passed down from grandmother and mothers and aunt etc writing about the rich indigenous culture. It is also important to note that during umqombothi preparations these women always wear *iduku* (head scarfs) and *umhlonipho*, a scarf that went across the chest as a symbol of showing respect to the ancestors.

3.6.2. Milk Fermentation (Amasi)

Amasi, which is made from raw cow's milk is a product that is produced by fermenting (add milk in a calabash and leave it at room temperature for 2 to 3 days to turn sour), a culture that has been taken from generation to generation. Milk fermentation is initiated due to Lactic acid bacteria that convert milk to a probiotic and induces activation of proteolytic enzymes. Lactase is very important for milk lactose digestion, but proteases function, as regards to milk proteins such as casein are, minimized in comparison. Its cultural value lies in the fact that such a product as simple as a porridge, *uphuthu*, is usually rich in nutrients. Besides, it is commonly administered to infants during weaning and used to relieve conditions of the digestive system.

3.6.3. Use of Medicinal Plants Containing Enzymes

Umhlonyane (Artemisia afra) is a local medicinal plant, often used to combat cold and flu. Results reveal that there are compounds in umhlonyane which may influence how the enzymes that regulate inflammation work. This folk medicine adopts Ikhatzo (Tulbaghia violacea) for use in treating hypertension and infections. Some of its components are said to be of value as enzyme inhibitors. These plants which are not specifically used for their enzymatic action are however said to have uses of "cleansing", "breaking down" or "stimulating", suggestive of their use at the biochemical level.

3.6.4. Practical Treatment and Softening of Animal Skins

To soften animal hides, old methods would involve soaking it in specific plant juices or allow it the age process in natural materials which ferment aging the hides to softness. Using enzymes to break down the proteins and fats makes the hide easier on shaping and making it useable. Culturally, the processed hides are used to make traditional clothing, to build drums and make shields (isihlangu).

3.6.5. Meat Tenderizing

Zulu Indigenous Knowledge reveals a practice of tenderizing meat using plants like wild figs, possibly containing protease enzymes. Although not always documented in scientific records, the Zulu people knew about these plants, which were used in agriculture, medicine, and material creation. El Yazidi and Rijal (2024) suggest that as Indigenous Knowledge is incorporated into science education seamlessly, it enhances ecological and cultural awareness helping the learner internalize knowledge on all three levels of cognition emotion, action.

3.7. Teaching Enzymes in Life Sciences from an Indigenous Perspective

According to CAPS, teachers need to create a strong foundation on how enzymes work as biological catalysts if they will successfully teach learners about enzymes in Life Sciences. Enzymes are specialised protein molecules that speed up chemical reactions without being destroyed during the process (Morris et.al., 2022). The same way people in the modern days dip saucers in a boiling tripe to soften it during traditional ceremonies can also help us understand how enzymes work and thus relate to what catalytic function an enzyme plays.

Educators make it easier for learners to understand when visuals, schematic presentation, diagrams depicting how enzymes are designed and how they move are incorporated. Hands-on lab activities explain the way of working of the enzyme, e.g. by the rate of food decay (Jones & Smith, 2024). The study suggests that teaching enzymes through Indigenous food rituals and medicinal uses can enhance learners' understanding and create an active learning atmosphere. It suggests that case studies and discussions about natural enzymes transcend Western scientific frameworks.

3.8. Research Design

Using systematic qualitative ethnographic research approaches, we studied and observed the Zulu culture of people from Kwa-Dlangezwa. The first author of this article belongs to this community; she participated in communes and ceremonies and became immersed in the practices to understand the behaviors of the inhabitants more and to know more on indigenous Zulu enzymatic rituals and beliefs. The main method of this research was to watch and hold conversations with the indigenous community. In this way, the researcher was able to get into the community's elders' good books and gain knowledge not accessible through interviews by doing so.

The attention to the communities of interest meant that the villages would be the main locations for our research. The main strategy used by ethnographers is the acquisition of qualitative information such as field notes, interview responses, audiovisual materials (Rizzo & Bresciani, 2024). Open ended questions allowed researchers to develop detailed descriptions of indigenous food preparation/ preservation in cultural, social and historical terms. The analysis also involved examination of enzyme literature, IK and evaluating its divergences from modern body of modern enzymatic research. Capacities were identified in which IK integration could greatly add to understanding.

While identifying suitable Indigenous peoples and relevant knowledge, the research assessed how previous literature on enzymes were studied in both historical and modern terms.

3.9. Research Paradigm

The research used a typical postcolonial paradigm by authors Chilisa, (2012 p.21) to provide a depth of insight into ethnographic research. Under Afrocentricity where “this perspective is rooted in, centered on, and located within every facet of African culture, be it mystical, societal, political, or economical. The paradigm upholds this worldview (Asante, 2022). To comprehend African realities, teachers of Life Sciences must be conversant with various African cultures, methods of knowing and practice to better serve their students. For this reason, it is crucial to translate enzyme concepts and theories in the context of African culture. Therefore, using the Afrocentric theoretical approach implies the consistency of the latter with the indigenous epistemology, which is focused on, and gives preference to, knowledge and experiences of the researched indigenous communities. Most indigenous paradigms have a basis in local ontology, epistemology, methodology and axiology (Harriden, 2023).

The study investigates indigenous food processing using enzymes in Kwa-Dlangezwa communities, aiming to understand their thinking and the significance they attach to their natural resources. The researcher used indigenous research methodologies to build close relationships with the communities, respecting their traditions and customs. The research aimed to preserve traditional knowledge and improve education in secondary schools. The researcher participated in traditional ceremonies like umemulo, demonstrating respect and creating stronger relationships. Over seven days, the researcher stayed in the community and documented sessions with the women, preserving meaningful cultural stories. The study also highlighted the importance of papaya and pineapple trees as local resources, recognizing and preserving IK.

This favoured the researcher’s purpose as an ethnographer to develop a clear understanding of the enzyme’s resources, extraction techniques and food preparations using indigenous enzymes. Indigenous communities’ language, historical background, values and expectations that they held close to their heart were observed and noted. This was to bring awareness of its effect on the research process and knowledge generation (Ablavsky & Allread, 2023) (. For the researcher to access their IK, respect and obedience for these indigenous communities’ heritage was paramount. Their communication, greetings, introduction, and ways of imparting knowledge to others were to be further acknowledged.

As indigenous researchers, it was crucial to consider the communities’ role in answering research objectives, involving techniques, gathering information, data evaluation and understanding distribution (Moahi, 2022). Traditional wisdom is viewed as an appropriate foundation of methodology and conceptual framework directing the study in this method. Some of the examples of the techniques include: “participatory, liberatory, and transformative techniques that rely on indigenous knowledge systems” (Chilisa, 2012, p. 41). They are participatory as they seek to involve the research participants in all aspects of the research and recognise their knowledge and the contribution it could make. The liberatory methodologies seek “to legitimize the histories, worldviews, and ways of knowing, and experiences of the colonized and historically oppressed” (Chilisa, 2012, p. 41). Indigenous approaches aspire to be transformational by conducting a study that is encouraging and beneficial to teachers and learners instead of merely discovering (Bullen & Roberts, (2021).

Indigenous authors like Marovah & Mutanga, (2024) believe in an indigenous research approach paradigm that promotes the ethical concept of Ubuntu as an example of an indigenous research epistemology. This indigenous research paradigm was identified as an aspect that embodies African methods of understanding the real world, values, beliefs, and research techniques like ethics consideration (Chilisa,2012).

3.9.1. Indigenous Epistemology

Adewusi, Asiimwe & Odekeye, (2024) defines the epistemic approach as "styles of contemplating, comprehension, and accessing wisdom" (p. 112). According to Kovach, (2021), "epistemology as one of the aspects of indigenous methodologies, is a field that deals with techniques for understanding, especially about the limitations of what is understood". Consequently, indigenous epistemology is concerned with integrating indigenous viewpoints at the heart of exploration, acknowledging the need to include alternative ways of understanding in the current study. On the other hand, ontology addresses perception and what defines the real world, what makes up understanding, and how it can be synthesised and verified (Chatterjee, Prinz, Gerdes & Martinez, 2021 and Ylönen & Aven 2023).

Indigenous epistemology focuses on incorporating indigenous perspectives in exploration, acknowledging the need for alternative understanding. It challenges Western epistemologies that "Other" people from indigenous backgrounds, aiming to uncover the good in every situation. Aboriginal epistemology is a fluid approach based on storytelling, traditional languages, visions, and fantasies, accepting knowledge from direct conscious experience and spiritual information (Chambers & Demir, 2024).

Sampling A basic sampling technique based on probabilities was used. The method was chosen because there is a comparable likelihood that every member of the Kwa-Dlangezwa indigenous community would be included in the sample bracket that includes the whole population. Probability simple random sampling looked appropriate for ethnographic research (McCombs, 2019). Three women from the Kwa-Dlangezwa indigenous community, including MaShamase, uKa Mabaso, and MaZwane, share traditional methods of extracting and applying natural enzymes. MaShamase uses green papayas to extract papain enzyme, while uKa Mabaso uses papaya leaves for papain-intensive herbal brews. MaZwane extracts bromelain enzyme from pineapples, which is used to tenderize meat, improve dish flavor, and treat digestive issues.

3.10. Data Collection

The study focused on ethnographic fieldwork in Kwa-Dlangezwa, observing enzyme extraction and use in domestic and cooking environments. The researcher developed good relations with local indigenous women and participated in ceremonies. They conducted semi-structured interviews in isiZulu, translated into English, and recorded verbal and non-verbal information. The study compared contemporary enzymatic products with locally or indigenous-produced enzyme preparations. Data validity was ensured through field notes, audio recordings, and visual data. The study provides a comprehensive understanding of enzyme extraction and use in indigenous communities.

3.10.1. Enzyme Extraction from Pawpaw Fruit is Papain

For decades, Kwa-Dlangezwa indigenous societies have used traditional methods to extract papain enzyme from papaya or pawpaw fruits. Papain, an enzyme that degrades proteins in green papaya, has various cooking and therapeutic uses. It softens meats, produces chewing gum, and marinates meat before flame grilling. This research reveals traditional methods for extracting papain enzyme from papaya.

The Kwa-Dlangezwa indigenous communities normally harvest these green papaya fruits from papaya trees in their own homes and use them immediately. This, according to MaShamase, whom she preferred we call by the clan's name, "MaShamase" had this to say:

"I normally pick and use green and unripe pawpaws from the tree. The reason why is because green pawpaws contain greater levels of papain-enzymes than ripe ones do. I then cut the pawpaws after harvesting in a way that allows leveraging as much fruit juice as possible. I cut the skin of the green pawpaw in a crisscross pattern; this enables the latex to come out in large quantities. I will then use a small bowl to scoop the natural (latex) milk from the previously cut papayas in crisscross fashion and dry it. I will achieve this by applying it evenly on my clean non-metallic kitchen table surface. For this case, I will put what I demand on the top of a kitchen cupboard. We will let it dry. I chose my kitchen since this is a good place because it is cool, breezy, and shaded. To prepare this papaya milk, I close the curtain through which the sunlight enters so that the enzymes do not spoil."

We waited for the latex to dry and came back. MaShamase furthermore demonstrated the fine powdering of this latex once it was dried. She collected it from the surface and started to ground it into a fine powder using "*itshe nembokodo*" (a stone and mortar).

Figure 1: Itshe nembokodo.

MaShamase then kneeled and started grinding the dried latex into powdered papain enzyme that was collected and stored in containers as powder, sealed and protected from humidity and light rays.

3.10.2. Application of Enzyme Papain in Food Preparation

The enzyme papain was used for softening meat from slaughtered livestock during traditional ceremonies. According to MaShamase, the papain powder is added to uncooked hard raw pieces of meat before they are cooked so that the pieces become tender. The papain enzyme role is to digest and split the meat protein fibres, tenderize the meat and make it easy to chew and digest. MaShamase showed that the juice of the green pawpaw (papain enzyme), has now been altered from natural fruit juices to marinades, wherein the juice is mixed with other ingredients such as tomato paste, garlic oil and salt to make meat marinates. The papain enzyme softens the unripe meat and gives it a flavor. Popular marinades for meat in traditional dishes that utilize papain are used to meet taste and tenderness.

MaShamases' neighbour uKa Mabaso gave extra details about their traditional way of preparing leaf tea from papaya tree leaves.She enlightened us with the fact that they sometimes made use of papaya leaves for tea. Following is her narration:

"*Depending on a season, sometimes the trees do not produce enough fruits. To extract this type of enzyme, an alternative method is employed since papain found in the leaves of the tree can be used in medicine as well as preservation of food. Medicinally, the tea from the papaya leaves enhances human immunity, and relieves bloating and indigestion. Papain is also very known for aiding digestion like black forest herbal tea especially, especially if one consumes much food than the body can accommodate. Its properties further prevent food from spoiling. The leaves of the trees are normally used because they are fully grown and readily available during harvest time. Ancient societies, Yap, (2022) explain, would convert the papaya leaves into tea by first air drying the papaya leaves and taking them to powder to obtain the papain enzyme. We still do this today."*

The skill of the indigenous peoples to extract and use the papain enzyme demonstrates their remarkable potential in the use of nature for therapeutic end use. While papain has numerous advantages, anyone with allergies or sensitivities should be cautious when ingesting foods that have this papain enzyme. Some food items can benefit from using papain as a natural preservative (Koul et.al., 2022). This method is useful to teachers as a means of including traditional enzymes in their Life Sciences laboratory sessions. The papain enzymes can be used in Life Sciences labs to preserve living specimens, thereby cutting the costs of chemicals like formalin. To study the internal anatomy of some organisms, Life Sciences students sometimes dissect animals such as rats. To prevent decays of dissections, it is advisable to use papain enzymes as a natural preservative instead of formalin which the indigenous group always apply on the foodstuffs to preserve the food and extend the shelf life of such products such as shellfish.

3.10.3. Enzyme Extraction and uses of Bromalin from Pineapple Fruit

Other indigenous communities around Kwa-Dlangezwa plant pineapple trees in their yards for shade and for the purpose of producing the pineapples that produce bromelain enzyme used to soften the meat. This enzyme is also used in preparation of traditional dishes such as “mohodu, umnqushu and meaty bones”. MaZwane described the techniques she normally uses in carrying out bromalin enzyme extraction. Bromalin enzymes, similar with papain enzymes from papaya, have properties to split proteins contained in meat. This enzyme has various utilities including cooking and for medicinal purposes. MaZwane explained how bromelain enzymes are removed from pineapple fruits and their application in preparing native meals:

“*The journey begins with the choice of fully mature pineapple fruit from the trees. The mature pineapples with yellow are high in the water and water-soluble and have a lot of enzymes in it. Picked fruits are washed and peeled to remove thorny skin along with hard seeds. The pineapples are then cut into pieces. These pieces are ground using “itshe and mbokodo,” which are traditional tools used to grind corn. Bromelain enriched pineapple juice is made by extracting it from crushed pineapple slices. Solid part is separated from water using a clean cloth. Fermentation is sometimes caused by placing the juice at room temperature, in a process that causes a natural ripening. Vigilant guidelines of the fermentation process enable great control over the potency of enzymes. In other traditional methods, the juice may be dried in the sun to form a powder of the enzyme bromelain. “This enzyme powder is stored in a cool, dry place for future use.”*

3.10.4. The use of Bromalin Enzymes in Food Preparation

MaZwane further mentioned that bromelain enzymes are used as an organic meat softener:

“*As an aunt in Zulu matriarchal generations, I usually find new ways of preparing modern meals using what I get from nature. Before preparing food, I put pineapple juice on meat and soak it for a while before cooking it. The enzyme acts on protein-based molecules, and meat is softer but more delicious. To achieve both flavor and tenderness. The enzyme acts on protein-based molecules, and the meat is softer, but more delicious. To make the meat taste and be more tender. I often use pineapple in salsas and side dishes providing that Mediterranean flavor in my African cuisines. Bromelain enzymes will add a broader taste profile to both fruits and vegetables through its action. Medicinally I use pineapple for digestion because of its digestive properties. Sometimes I have drinks containing pineapple to support digestibility after a heavy meal. Pineapple and its bromelain-rich juice are used to add a refreshing tropical flavor to beverages, as well as sweetened beverages such as fruit smoothies, breakfast drinks, and cold drinks. Ancient societies use bromelain-rich juices to reduce bloating and relieve stomach pain. How indigenous people extract the bromelain enzyme from pineapples speaks volumes on how they’ve understood the use of nature for nutritional as well as medicinal purposes.”*

3.10.5. Data Analysis

Data for this study was analysed using both thematic and interpretive analysis. Thematic analysis was conducted to discover categories, patterns, themes and subthemes. The study probed into the root knowledge systems and broader socio-cultural meanings of the themes upon which research was set based on interpretive analysis.

This is a thematic analysis using Johnny Saldaña’s coding framework moves from from categorization to theming and sub-theming and showing how the data was interpreted and used to derive meaning (Lungu, 2022). The methodology based on the ethnographic and participatory paradigms lies on qualitative coding that is to reveal meaning, cultural subtlety, and practice. No qualitative data analysis software was used. rather, manual coding methods were used to remain at a close connect with the textual data and their cultural nuances.

3.10.6. How Saldana Coding Was Used

Coding helps researchers understand traditional practices by dividing complex processes into conceptual categories. These categories form themes that illustrate Indigenous practices' intersection with culinary, medicinal, and pedagogic domains. Saldana coding maintains indigenous voices, and sub-themes highlight practical applications in Life Sciences teaching, food preservation, and health benefits. Below a thematic analysis carried in the style of the coding method of Saldaña segmented into categories, themes, subtheme, and illustrative example emanating from the qualitative data surrounding extraction and application of Papain and Bromelain enzymes in the Kwa-Dlangezwa Indigenous communities, is written:

Table 1: Thematic analysis on categories carried in the style of the coding method of Saldaña.

Category	Description
Indigenous ways of enzyme extraction methods	Cutting, sun drying, and grinding using “*itshe nembokodo*” as traditional extraction techniques.
Enzymatic culinary use	Papain and bromelain used in meat tenderization, food preparation, and making marinades.
Medicinal and preservative use	Enzymes used in teas, digestive aids, and as preservatives in foods such as nuts.
Traditional tools	“*itshe nembokodo*” significance and their role in cultural rituals and traditional activities.
Research tools (Tertiary data)	Use of participant observation, interviews, visual data, and field notes to collect ethnographic data.
Intergenerational knowledge transfer	Elders, IK knowledge keepers and matriarchs as key figures in conserving and passing down indigenous knowledge.

3.11. Themes and Sub-Themes

Table 2: Thematic analysis on themes and sub-themes carried in the style of the coding method of Saldaña.

Themes	Sub-themes
Theme 1: Enzymes use indigenous knowledge systems	Sub-theme 1.1: Custodianship of knowledge, women like (Mashamase, Kamabaso and Mazwane) are gatekeepers to the traditional knowledge. Sub-theme 1.2: Localization of scientific processes extraction of enzymes follows contemporary biochemical methods and is locally adapted.
Theme 2: Functional and ideational uses of enzymes	Sub-theme 2.1: Functional: meat tenderizing, cooking aid enzyme's practical culinary purposes: Enhance flavour in food and beverages and softens meat. Sub-theme 2.2: Symbolic and ritual enzyme use is entrenched in social affairs of ceremonial food preparations.
Theme 3: Enzyme knowledge as living practice	Sub-theme 3.1: Community-based experimentation based on the environment, participants modify methods (e.g. drying enzymes in shaded kitchens). Sub-theme 3.2: Integration into modern contexts Usage of restaurant, classrooms, and commercial teas (e.g., formalin substitutes).
Theme 4: Ethnographic research and immersion into indigenous communities and data authenticity.	Sub-theme 4.1: Reflexivity and researcher's role in immersion and relations, made data collection qualitatively and authentically rich. Sub-theme 4.2: Multimodal data collection employing of audio, visuals, notes and language translation increased data richness.

4. DISCUSSION OF FINDINGS

Thematic analysis reveals a deep rich image of how the Indigenous communities of Kwa-Dlangezwa, Empangeni, in KwaZulu Natal sustainably use natural enzymes from pawpaw and pineapple fruits through involved culturally sophisticated practices. The participant discusses the precise extraction, storage and culinary/medicinal uses, explanatory of how Life sciences education and health care systems, and food preservation systems may incorporate. The bridging theme is the intertwining of practicality, sustainability and cultural perseverance involved. The information gathered in the field shows main results about Indigenous knowledge and practices in enzyme extraction and use in the Kwa-Dlangezwa communities, namely in papaya and bromelain, respectively. Below is the summary of the top findings:

1. Indigenous Knowledge of Enzyme Extraction

Papain enzyme extraction involves harvesting the latex from unripe papayas, which is then dried and pulverized using traditional grinding tools. If fruits are unavailable, papaya leaves are dried and ground to obtain the enzyme. Bromelain enzyme extraction involves peeled, chopped, and crushed pineapples, which are then dried into powder using a conventional grinding machine. The enzyme-rich juice or powder is stored in a cool, dry environment. This method demonstrates the principles of science through hands-on methods, supporting Specific Aim 2 in the Life sciences CAPS curriculum. It helps teachers improvise by offering locally available materials and teaching aids, promoting learning alongside traditional procedures and fostering appreciation for scientific knowledge based on local culture.

2. Culinary Uses of the Enzymes

Papain and bromelain enzymes are used to tenderize hard meat by degrading protein fibers, shape, and taste. Papain is used in meat marinades, while bromelain is used in salsas, side dishes, and traditional sauces. These enzymes link Life sciences to daily life experiences and support interdisciplinary learning in biology, food, medicine, and cultural studies.

3. Medicinal Uses of Herbs

Papaya leaf tea and papain enzymes aid digestion and immune system building, while indigenous people preserve meat and seafood using papain for preservation. In Life Sciences education, papain is suggested as a cost-effective substitute for formalin in labs, promoting environmental awareness and promoting the use of natural substances in everyday life.

4. Cultural Relevance and Sustainability

This thorough knowledge of natural cycles and biological functions constitutes a high degree of traditional' expertise'. Harvesting practices calls for environmental awareness in sustainability (when fruits scarce leaves used). Gender Roles & Oral Tradition points that indigenous Knowledge is passed orally, and it is led by women such as MaShamase, kaMabaso and MaZwane.

The Life Sciences curriculum emphasizes the significance of matriarchal narratives and oral stories in scientific discourse, promotes IK integrated teaching methods, and supports hands-on environmental conservation techniques. It also respects learners' cultural and life backgrounds, aligning with Aim 3 in the Life Sciences CAPS curriculum.

4.1. Pedagogical Strategies for IK Integrated Implementation

Project-based learning in Life Sciences, part of the CASS mark, encourages relational learning by involving local experts and promoting a personalized learning experience. This approach enables learners to compare scientific knowledge and indigenous wisdom for enzyme use, creating a decolonized, practical, and inclusive scientific education approach. Integrating research findings into lessons aligns with scientific, indigenous knowledge, and integration objectives, promoting a decolonized, practical, and inclusive learning environment.

Table 3: Pedagogical strategy for IK integrated enzymes lesson implementation.

Classroom activity plan: Exploring enzymes through indigenous knowledge	
Grade level: Grade 10 life sciences	
Duration: 2–3 Lessons (60 minutes each)	
Topic: Enzyme Function and Indigenous knowledge of Papain & Bromelain	
Learning objectives: At the end of the lesson learners are expected to:	
Scientific objective	Understand enzyme activity, particularly the role of proteases (papain & bromelain) in protein breakdown and digestion.
Indigenous knowledge objective	Explore how indigenous communities extract and use enzymes from papaya and pineapple for culinary and medicinal purposes.
Integration objective	Demonstrate how scientific concepts of enzyme function are embedded within indigenous practices, promoting biocultural understanding and relevant science education.
Improvised Learning and Teaching Support Materials (LTSM)	
• Fresh green papaya and pineapple • Raw meat slices • Mortar and pestle or “itshe nembokodo” replica • Small bowls, cloth strainers, cutting knives • pH strips (optional), magnifying lenses • Written excerpts from participant interviews (e.g., kaMabaso, MaShamase, MaZwane) • Worksheets for observations and reflections	
Teaching strategies	Teaching methods
Teacher centred approaches	Demonstration, Lecture methods
Learner centred approaches	Experimenting
Lesson presentation	
Teacher activity	Learner activity
Scientific objective Introduction • Starter Discussion: Ask students if they know how meat is softened in their homes. Alternatively, teacher may play a 5–10-minute video/read short narratives from kaMabaso/ MaZwane/ MaShamase on how papain / bromelain are extracted from fruits. • Visual aids: Show photos or tools (like itshe nembokodo) used traditionally to capture learners’ interests. • Content Presentation: Teach scientific concepts as required by Life sciences CAPS curriculum. • Introduce enzymes, define, discuss types and sources, functions, and enzymes found in digestive tract. • Discuss properties of enzymes • Discuss lock and key Model using a key and a locker.	Draw enzyme substrate complex and ask learners to pick and use the matching labels to stick to the enzyme substrate complex to the board
Indigenous knowledge objective Introduction: Give each learner a piece of bread to put in the mouth for 5 minutes without swallowing it. This allows them to have a first-hand experience on how salivary amylase breaks starch from bread into simple sugars Content Presentation: Demonstration for learners • Read instructions while demonstrating the experiment. • Step 1: Extract papain (from green papaya latex) or bromelain (from crushed pineapple) using traditional or modern tools. • Step 2: Apply enzyme-rich juice to raw meat. • Step 3: Observe changes in texture over time (can test with softness, pH if available). • Step 4: Document process (drawings, notes, photos).	Allow learners to perform an experiment on their own in groups. • Divide the class into small manageable groups and ask them to follow instructions from worksheets. • Step 1: Extract papain (from green papaya latex) or bromelain (from crushed pineapple) using traditional or modern tools. • Step 2: Apply enzyme-rich juice to raw meat. • Step 3: Observe changes in texture over time (can test with softness, pH if available). • Step 4: Document process (drawings, notes, photos). *Indigenous women's extraction and processing demonstrate science principles through hands-on methods, supporting Specific Aim 2 in Life sciences CAPS*

curriculum. It encourages comparative learning using traditional tools and presents eco-friendly specimen preservation methods.

Integration objective

Reflection & Integration:

- Divide learners into groups
- Give learners topics for discussion
- Supervise discussions

Group discussions

- *Compare enzyme-treated vs. untreated meat.*
- *Class discussion:*
  - *What did they observe?How does this relate to digestion in the body?How does this show science in indigenous practice?*
- *Write a short reflective paragraph answering:*
  - *"What did I learn about enzymes from science? What did I learn from indigenous knowledge? How are they connected?"*

This activity connects Life sciences to daily life experiences, supports interdisciplinary learning, and instils appreciation for local culture through cooking experiments and enzyme reactions.

Assessment

Scientific objective

Assessment Tool	Measures
Classwork Homework	Understanding of the content

Classwork

Knowledge & Understanding

1. What are proteases, and what role do they play in digestion?
2. Name two natural sources of protease enzymes mentioned in the lesson.
3. What is the function of papain and bromelain in protein digestion?

Application

4. How does papain soften meat on a molecular level?
5. Why are green papayas more effective in extracting papain than ripe ones?
6. What changes would you expect in a piece of raw meat treated with bromelain?

Analysis

7. Compare and contrast how papain and bromelain act on meat proteins.
8. Why might enzyme-treated meat cook faster than untreated meat?

Indigenous knowledge objective

Assessment Tool	Measures
Experiment &Observation worksheet	Understanding of enzyme extraction process using traditional methods

Learners complete experiment worksheets

ESSAY

How do Indigenous communities traditionally extract and use enzymes from papaya and pineapple for culinary and medicinal purposes?

ASSIGNMENT

Discuss the traditional methods used by indigenous communities to extract enzymes from papaya and pineapple. In your answer, explain how these enzymes are applied in both food preparation and medicine.

Integration objective

(Comparing the Eurocentric and indigenous perspectives)

Assessment Tool	Measures
Group presentation	Ability to relate science to indigenous practice
Reflective writing	Depth of integration and respect for IK

Presentations:

Critical Thinking, Comparing & Integration

1. How could the knowledge of enzyme activity from indigenous practices be used in modern biotechnology or food preservation?
2. What are the potential risks or limitations of using natural enzymes like papain and bromelain in food preparation?
3. How do traditional enzyme extraction methods align with scientific principles of enzyme activity?

Extended Opportunities

- Use the enzyme to preserve fruit or meat over days and compare spoilage.
- Discuss allergies and sensitivities (papain/bromelain) to integrate health sciences.
- Connect to environmental education: sustainable use of natural resources.

The study aimed to explore teaching enzymes in Grade 10 Life Sciences complemented with aspects of IK integration. These findings were then compared to literature and CHAT, to explain the extent to which the research supports existing knowledge and reveal the limitations of the current educational practices.

The study is a fill to the literature, affirming the necessity of incorporating IK into conventional science education. While scientific literacy and problem-solving are taught more prominently, there is still a lack of reference to IK in the Life Sciences in CAPS. The authors El Yazidi & Rijal, (2024) argues that incorporating IK into science education enhances the acquisition of ecological and cultural appreciation that, in turn, makes for a holistic learning approach to science. This is apparent in the current study, whereby IK incorporation of enzymes, including processes like indigenous ways of extraction and use of enzymes in everyday life, can help to improve learners' understanding of enzyme action. A corollary to Dwivedi et al.'s (2021) argument, the use of IK both increases learners' cultural awareness and deepens appreciation for scientific progress because it adds cultural views to education. The study findings support these assertions as learners exposed to enzyme processes through local and traditional food processing techniques can have an expanded and interesting biochemical understanding.

The study supports the use of CHAT in Life Sciences learning, highlighting its relevance in understanding enzymes. By decolonizing cultural-historical activity, learners can connect scientific content with their cultural realities. The study highlights the importance of cultural tools, language, and interactions in shaping learning. By incorporating cultural practices, learners can enhance their understanding of enzymes and their role in biological activities (Leontiev & Engeström, 2022).

The study supports the application of Interactive Knowledge (IK) in biological processes, such as food processing and meat softening. It highlights the importance of enzymes in traditional techniques, such as extracting and preserving food. IK can enhance learners' understanding of scientific and cultural aspects of enzymes, particularly in diverse cultures. This aligns with the findings that IK can enhance cultural sensitivity and context learning in teaching enzymes and their role in food processing (Arba, 2019)

The CAPS document underscores the need to establish an appreciation of what enzymes mean to be chemical biological catalysts. However, the review of CAPS shows no clear guidelines on how teachers can incorporate IK in teaching enzymes. This study showed that CAPS significantly omits IKS and practices in classrooms and teaching instead of models borrowed from developed Western contexts (Molise, 2025).

The study suggests incorporating Indigenous Knowledge (IK) into enzyme lessons, highlighting the need for a more inclusive curriculum that integrates scientific and IKS. The curriculum lacks consideration of indigenous practices, such as enzyme extraction and fermentation, which hinders linking learners' cultural experiences with scientific information. IK holders can be used to explain traditional enzyme practices. These resonate with literature because research shows that incorporating relevant real-life examples, such as traditional food processes, into the teaching of sciences can elicit learners' interest and improve their learning and understanding of sciences (Mlotshwa & Tsakeni, (2024).

The study highlights the importance of using traditional food processing methods like fermentation in teaching Life Sciences concepts, reducing abstract biochemical processes and incorporating indigenous practices, to provide more valuable and culturally related learning activities.The above approach supports Dwivedi et al.'s (2021) argument that looked at how culture-based knowledge could be incorporated into mainstream science education to improve learners' general perception of the two fields.

4.1.1. Trustworthiness

The study in Kwa-Dlangezwa was built on ethical research principles, focusing on community involvement and cultural respect. Regular feedback sessions and co-researching with community members ensured the results aligned with their ideas. Ethical practices, such as informed consent and patient confidentiality, made the results trustworthy and reliable (Weiner, Dankwa-Mullan, Nelson & Hassanpour, 2025).

4.1.2. Validation and Ethical Considerations

The researcher obtained informed consent from Indigenous participants for an ethnographic investigation, respecting cultural customs and traditions. They highlighted the importance of protecting pawpaw and pineapple trees for enzyme extraction and the benefits of local wisdom. Data triangulation was conducted to validate interpretations and cultural accuracy. After ethical clearance and informed consent, fieldwork began, with a focus on maintaining indigenous intellectual property and cultural protocols (Weiner et.al., 2025).

5. CONCLUSION

The study explores the use of Indigenous Knowledge (IK) in Grade 10 Life Sciences education, highlighting the benefits of incorporating indigenous perspectives. It suggests that incorporating IK in the curriculum can enhance learners' understanding of enzymes and their cultural context, strengthening their ties to their heritage. The adoption of IK can create a classroom that appreciates various ways to understand nature and bridge the gap between traditional Western science teaching and IK. The study also highlights the importance of using localized practices like food softening and fermentation in delivering enzyme knowledge. The study provides a lesson plan guideline for teachers to incorporate IK in their teaching methods.

6. LIMITATIONS

Nevertheless, studying has some drawbacks. The main method of data collection in the approach is qualitative data collection which may limit the way people have to take overview of the attitude people have toward the integration of IK in various settings. Also, concentrating on specific content could limit how broadly the findings apply. Future studies could gain from larger research that examines various educational settings and the long-term effects of including IK in science lessons.

7. RECOMMENDATIONS

7.1. IK Integration

By understanding enzymes from a cultural perspective, this research aims to contribute to improving or enhancing Grade 10 Life Sciences to promote inclusive education and appreciation of IK. The study suggests that teachers could start by formulating one or two IK-related objectives to integrate IK in the teaching of enzymes better.

7.2. Future Research

The study suggests further research on the impact of Indigenous Knowledge (IK) on learners' performance in the Life Sciences curriculum. It also suggests exploring its application in other aspects of science and documenting indigenous enzyme knowledge. The study encourages collaborations between researchers from diverse cultural backgrounds and local indigenous communities. It also calls for advanced teaching strategies that incorporate indigenous wisdom into the study of enzymes. The findings have implications for developing Life Sciences curricula and teaching practices. Teachers need to be knowledgeable about their learners' characteristics and heritages to design engaging lessons. Curriculum designers should consider this integration to improve their subject matter knowledge.

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