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Life sciences learners' views on the integration of indigenous knowledge into indigenous knowledge-related topics using a cooperative learning approach: A case of South African grade 10 classroom

Thabelang Segopotse Sefoka [1], Karabo Justice Chuene [1*]

[1] University of Limpopo, Polokwane, SOUTH AFRICA

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Abstract

This study explored grade 10 life sciences learners' views on the integration of indigenous knowledge (IK) into IK-related topics using a cooperative learning approach. The study was underpinned by social constructivism theory, whereby a qualitative single-case study design was used. Eight grade 10 life sciences learners from a school in Moroke Circuit, Limpopo Province, participated in the study. Document reviews and observations were used to collect data. The findings revealed that the teaching methods under the cooperative learning approach are efficacious in integrating IK in the life sciences classroom. The findings further revealed that the integration of IK in life sciences classrooms improved participation, learning, and comprehension of life sciences topics and that when learners are given space and a voice, they are able to express critical and independent views from which teachers can draw a lot from. The study recommends changes towards curriculum development, teacher training, classroom strategies and community engagement.

Keywords: cooperative learning De Bono's six thinking hats, indigenous knowledge, jigsaw, life sciences, social constructivism

INTRODUCTION

Over the past two decades, researchers, particularly in South Africa, have advocated for the recognition of indigenous knowledge (IK) and its significant role in science curriculum (Odora Hoppers, 2021; Senanayake, 2006). As policymakers began considering the inclusion and integration of IK into science through the life sciences Curriculum and Assessment Policy Statement (CAPS) (see Department of Basic Education [DBE], 2011). As more scholars focused their research on appropriate teaching strategies for its successful integration. Argumentation was one such teaching strategy considered (Hewson & Ogunniyi, 2011; Otulaja et al., 2011). However, it was concluded that argumentation as a teaching strategy had little prospect of successfully integrating IK into science classrooms (Easton, 2011). Researchers such as Cronje (2015), Reddy (2018), and Sebotsa (2020) explored science teachers' views on IK and their ability–or lack thereof–to integrate it into science classrooms.

Despite the attention given to IK through research on teaching strategies, teacher perspectives, and readiness for integration, South Africa continues to demonstrate a need for studies focusing on how learners engage with IK-related topics (McKnight, 2015). This need is particularly evident in understanding how IK can be integrated using a cooperative learning approach in science, specifically in grade 10 life sciences classrooms.

IK is defined as the knowledge that local communities have accumulated through daily observations, experimentation, and interactions with their surroundings (Rankoana, 2017). It is passed down orally from generation to generation and is specific to each culture (Senanayake, 2006). According to Zidny and Eilks (2018), this type of knowledge is critical for local livelihoods and survival. Learners, as members of their communities, carry this knowledge into their classrooms (Mawere, 2015), including life sciences classrooms. In this study, IK is viewed as learners' pre-existing knowledge, descriptions, understandings, and explanations of the world around them, derived from

✉ thabelangsefoka@gmail.com ✉ karabo.chuene@ul.ac.za **(*Correspondence)**

Contribution to the literature

- The literature of the study revealed lack of empirical literature that focus on South African life sciences learners' responses and classroom performance through IK integration.
- The findings of this study contributed to the body of knowledge by revealing the importance of learners' contextual experiences in the classroom.
- The use of cooperative learning approach to integrate IK affords learners opportunity to express critical and independent views.

their communities, which can be used in the classroom to enhance subject comprehension.

Integrating IK into life sciences classrooms is not straightforward, as the life sciences CAPS document does not specify which teaching strategies should be used. Additionally, learners and teachers possess varying IK that is not easily accessible (Diwu & Ogunniyi, 2011; Mothwa, 2011). Jacobs et al. (2016) advised that pedagogies promoting cooperative learning should be employed to facilitate IK integration in life sciences classrooms. Consequently, this study adopts a cooperative learning approach, which involves using teaching methods that encourage active learning within small groups where ideas are exchanged and debated (Johnson & Johnson, 2014). In this study, cooperative learning refers to teaching strategies that divide learners into small, face-to-face groups to discuss, debate, and clarify their understanding of concepts. It simply means learning in groups; therefore, the jigsaw teaching method and De Bono's six thinking hats approach were chosen. Johnson and Johnson (2014) emphasize that cooperative learning incorporates face-to-face interaction, self- and group reflection, constructive interdependence, individual accountability, and the development of interpersonal and social skills. These characteristics align with IK, which is primarily transmitted orally and involves social engagement and learning. In agreement, Jautse et al. (2016) asserted that cooperative learning is prevalent in IK settings.

Rahmawati and Ridwan (2017) conducted a study to empower learners and help them connect with their IK by integrating ethno-chemistry into chemistry lessons. Learners reflected on this approach, noting that it provided meaningful learning experiences that fostered critical self-awareness of their cultural identity and character development within a curriculum-relevant context. This finding aligns with the argument that learning becomes more engaging and relevant when learners can relate classroom content to their daily lives (Hammond et al., 2019). Similarly, Fakoyede and Otulaja (2019) integrated IK into life sciences classrooms by using beads and beadwork to mediate the learning of organic compounds, such as carbohydrates, lipids, and proteins. Their study explored learners' responses and expressions when interacting with cultural artifacts during lessons. The findings revealed that incorporating IK in the classroom helped contextualize science concepts, making them more relatable and enhancing learners' comprehension. Fakoyede and Otulaja (2019) further highlighted that learners' cultural, social, and symbolic capital supported their learning and facilitated a deeper understanding of scientific concepts.

Drawing from these studies, it is crucial to access learners' perspectives to leverage their existing knowledge and worldviews. This can serve as a foundation for strong teaching strategies that help learners recognize the connection between science and their daily lives (Pretorius et al., 2014). Integrating learners' IK into the classroom enhances subject learning and allows them to see the relationship between science and society (Abah et al., 2015; DBE, 2011). However, despite existing research, there remains a gap in studies that focus exclusively on how grade 10 life sciences learners engage with IK-related topics, particularly in South Africa. Therefore, this study seeks to address this gap by exploring grade 10 life sciences learners' perspectives on integrating IK into IK-related topics using a cooperative learning approach. Furthermore, this study focuses on topics such as "biosphere to ecosystems" and "application of indigenous knowledge systems." These topics encompass content such as biomes, traditional technology and skills, traditional medicines and healers, medical biotechnology, and cloning of plant and animal tissues (DBE, 2011; McKnight, 2015, pp. 52-53). The following research questions guided this study:

1. What are grade 10 life sciences learners' views on the integration of IK into IK-related topics?
2. How does the cooperative learning approach influence the integration of IK in the grade 10 life sciences classroom?
3. How relevant is the IK held by learners for the integration into life sciences?

LITERATURE REVIEW

We noticed that there is no universally accepted definition of Indigenous Knowledge (IK); hence, there are various terms that are used to describe it. Nicholas (2018) refers to it as traditional knowledge, traditional technology, traditional ecological knowledge, or native science. Similarly, Senanayake (2006) identifies IK as local knowledge, folk knowledge, people's knowledge, traditional wisdom, or traditional science. Senanayake

(2006) further emphasizes that IK is collective knowledge unique to specific people or cultures and varies from place to place.

This knowledge is derived from the environment, spirituality, culture, and history, playing a crucial role in the livelihood, survival, problem-solving, and decision-making of local communities (De Beer & Whitlock, 2009; Zidny & Eilks, 2018). Additionally, IK is considered a way of knowing developed by indigenous communities through daily interactions, observations, and experimentation with their surroundings (Mapedza et al., 2022; Rankoana, 2017).

However, in the context of this study, we define IK as learners' pre-existing knowledge, descriptions, understandings, and explanations of the world around them, derived from their communities. This perspective aligns with the fundamental principle of Life Sciences, which studies living organisms and their interactions with one another and their environment. Since learners are active participants in their environments, their IK can be effectively utilized in the classroom to enhance their understanding of Life Sciences.

Examples of IK That Maybe Integrated Into Life Sciences Classrooms

Mothwa (2011) highlights that there are many examples from South Africa's rich cultural diversity and biodiversity that can be used to illustrate the relationship between IK and Life Sciences. Such examples are suggested as excellent learning opportunities that will encourage learners to actively relate to and adopt this knowledge and integrate it into their daily lives (Van Wyk & De Beer, 2019). As Life Sciences teachers, we agree with the authors. Therefore, the emphasis below highlights some of these examples. For instance, IK bearers in Giyani, and Mopani districts within Limpopo Province have a sustainable and environmentally friendly solution for insects. For many years, the inhabitants of Giyani have used the plant Lippia javanica as an insect deterrent (De Beer, 2015). In collaboration with the inhabitants of Giyani, the Council for Scientific and Industrial Research (CSIR) of South Africa has filed a patent for the use of Lippia javanica as an insect repellent. In comparison to the commonly used citronella oil, which has a 40% effectiveness rate in clinical studies as a mosquito repellent, however, the oils found in Lippia javanica appear to be 95% effective (Van Wyk & Gericke 2018). Therefore, this is one of the examples that can be integrated into Life Sciences when addressing the effects of chemical pesticides.

Another example is the South African indigenous shrub healing plant, Sutherlandia frutescens (cancer bush), which is believed to radiate energy and well-being, cleanse the blood, act as a tonic, lessen flu symptoms, and have anti-cancer and anti-STI properties. In the current days is also used to treat AIDS patients, but it does not cure the disease; rather, it improves their quality of life. This is a fascinating illustration of how modern science is elevating the work of indigenous people. Furthermore, plants such as the Hoodia gordoinii are used by the Khoisan to cure abdominal cramps and to overcome hunger and dehydration (Van Wyk & Gericke, 2018). Lastly, other herbal plants such as Rooibos that cure a variety of diseases and the Marula fruit tree whose fruits have considerable amounts of oleic acids and antioxidants, as well as skin-healing and moisturising capabilities are also found in South Africa (Murye & Pelser, 2018; Van Wyk & Gericke, 2018).

Learners' Views About the Integration of IK

De Beer (2016) highlighted that learners do not enter the science classroom as blank slates. It is essential to recognize that they often possess important indigenous and personalized knowledge related to curricular themes, which must be explored (Jacobs, 2015). Thus, examining learners' views is crucial for realizing the potential of their IK, enabling them to contextualize science education (Anazifa & Hadi, 2017; Mansikonza, 2019). Consequently, learners actively contribute to the body of knowledge and increase their engagement as their IK competencies are explored (Havenga, 2019; Knapp, 2014; Zidny et al., 2020). However, caution is needed regarding potential confusion arising from the overlapping perspectives of the two knowledge systems, which may impact how learners engage with science.

Various studies on the integration of IK found that learners participated actively in activities and discussions drawing on their IK. Learners responded positively, expressing openness, willingness to share their views, and recognizing the relevance of IK in their lives and future applications (see Erinosho, 2013; Jacobs, 2015; Ugwu, 2016). Consequently, learners' perspectives provided teachers with valuable insights into their personal beliefs (Jacobs, 2015; Zidny & Eilks, 2020). Furthermore, a study by Onwu and Mufundirwa (2020) revealed that learners valued connecting local traditions to scientific ideas in the classroom. Understanding topics through cultural examples increased their interest in everyday local experiences and demonstrated the benefits of these experiences for science education. The study concluded that learning environments that facilitated discussions and critical engagement with IK improved learner motivation and engagement with scientific concepts.

However, a study by Manyana (2020) found that some learners did not perceive IK integration as relevant to their physical sciences lessons. They argued that while it enhanced class discussions and argumentation, it did not contribute significantly to their scientific understanding. These findings suggest that teachers must provide learners with opportunities to interact with scientific concepts from their socio-cultural perspectives before exploring their views on the integration process.

The above examples illustrate that while some learners' indigenous beliefs and viewpoints may lack scientific justification, they remain significant as they foster critical thinking in classrooms. Hence, improved learning occurs in environments that are culturally, cognitively, and linguistically supportive and meaningful (De Beer, 2019).

Cooperative Learning Approach and Considered Teaching Methods Under the Cooperative Learning Approach

According to Johnson and Johnson (2014), cooperative learning is a teaching strategy that employs various methods to promote active learning in groups, making learners responsible for their learning. To facilitate collaboration, learners are divided into small, face-to-face groups where they discuss, explore, refine, and clarify their understanding of concepts to achieve learning goals (Gillies, 2016). While limited research exists on the use of cooperative learning to integrate IK in Life Sciences with learners as the primary participants, studies by Jacobs (2015), Jacobs et al. (2019), and Knapp (2014) on teachers' ability to integrate IK through cooperative learning found that Jigsaw and De Bono's Six Thinking Hats methods enhance accessibility, participation, and comprehension.

Jigsaw enables learners to work in groups of four to six, where the teacher provides content for exploration, allowing learners to become experts in their allocated material (Dhull & Verma, 2019; Roseth et al., 2019). De Bono's Six Thinking Hats method, on the other hand, utilizes six metaphorical hats—white, red, yellow, black, green, and blue—each representing a different thinking approach.

Several studies have shown that Jigsaw encourages learners to take ownership of their learning, improves knowledge retention and retrieval, enhances understanding, and boosts academic achievement due to its interactive and collaborative nature (Baneng, 2020; Chukwu & Arakoyo, 2019; Ojekwu & Ogunleye, 2020; Oliveira et al., 2019; Sabbah, 2016). Additionally, the Jigsaw method is believed to develop learners' affective domains (Karacop & Diken, 2017). Nurbianta and Dahlia (2018) reported that this method motivated learners and increased their interest in learning. Researchers emphasize that learner interest is crucial in education, driving curiosity, engagement, commitment, and determination to succeed (Patesan et al., 2016). Thus, De Beer and Whitlock (2009) suggest that Jigsaw is effective for integrating IK with Western science, as it facilitates exploration of controversial issues and informed decision-making.

Similarly, research by Alghamdy (2019), and Nie and Aziz (2019) examined learners' perceptions of using De Bono's red, yellow, and green thinking hats technique to improve reading and comprehension in English classes. Their findings indicated that all participants found the technique engaging and useful. Furthermore, various studies have demonstrated that De Bono's Thinking Hats method enhances learner attitude, motivation, autonomy, communication skills, and brainstorming abilities (Animasahun, 2007; Han et al., 2019; Hani et al., 2017; Kaya, 2013; Khupe, 2017).

Theoretical Underpinning

The theory underpinning this study is the social constructivism theory by Vygotsky (1978), which holds that knowledge is actively constructed during social interactions. This theory was used to interpret the findings of this study, as such it is important to consider the tenets enshrined in the framework. McLeod (2018) indicates that social constructivist theory posits the teacher as the creator of learning environments that stimulate active interactions among learners. Hence, this study adopted cooperative learning approaches as a way to establish a learning context based on active engagements and interactions in groups, wherein learners can communicate their IK. Therefore, the components of this theory considered in this study are culture and language.

Culture

Culture encompasses all of a society's shared information, beliefs, attitudes, behaviors, and values (Idang, 2015). As such, Vygotsky (1962) indicates that learning cannot be isolated from its social and cultural context. Therefore, cultural tools such as language, traditions, and beliefs form an important base for learning within contexts. This study required learners to share their IK about life sciences content. Thus, allowing each learner to use their cultural tools to construct new knowledge in the life sciences classroom.

Language

Language is a set of written or spoken symbols that serve as the foundation for thinking, reasoning, and comprehension developed from social interactions (Vygotsky, 1962). It is seen as the ability through which we gain the ability to comprehend and communicate through speech. Therefore, Vygotsky (1987) listed three forms of language, which are social speech, private speech, and inner speech, used to organize thoughts and regulate behavior during social interactions. In the context of this study, language enabled learners to scrutinize the learning material to understand what was represented and required of them.

RESEARCH METHODOLOGY

Under this section we deliberate on the research approach, research design, and sampling used in the

Table 1. Biographical details of the participants

Participant	Gender	Age
L001	F	16
L002	F	16
L003	F	16
L004	M	16
L005	F	16
L006	F	16
L007	F	16
L008	M	16

study. Furthermore, we deliberate on the ethical considerations, quality criteria, and how data was collected and analyzed.

Research Approach, Sampling, and Research Design

This study used a qualitative research approach, which enables researchers to explore, discover issues about a particular phenomenon from participants' point of view in their natural settings, thus, allowing for an in-depth analysis of the their responses (Bhandari, 2020; Haradhan, 2018). We used an exploration single case (Stake, 1995). This study used a purposive sampling where only eight learners, from a class of 69 grade 10 life sciences learners willingly agreed to be part of this study. Purposive sampling is a sampling technique by which a deliberate choice of a participant is made due to the qualities the participant possesses, and it offers the opportunity for typicality, variety, accessibility, and learning opportunities (Etikan et al., 2016; Stake, 1995). Therefore, the learners were sampled on the basis that they were grade 10 life sciences learners from a particular high school stationed within the Moroke Circuit, Limpopo Province, South Africa and were willing to participate in the study. Furthermore, this study used documents, and participant observations to collect data from the learners' point of view.

Quality Criteria and Ethical Considerations

According to Frambach et al. (2013, p. 552) credibility is "the extent to which the study's findings are trustworthy and believable to others", which can be accomplished through triangulation, which is defined as the use of several data collection instruments (Frambach et al., 2013; Schumacher & McMillan, 2010). In the context of this study, data triangulation was accomplished through collecting data using documents, and participant observations. To address the aspect of dependability, which is "the extent to which the findings are consistent in relation to the contexts in which they were generated" (Frambach et al., 2013, p.552). We focused on data saturation where we collected data to an extent where there were no new themes. Furthermore, issues of ethics are central in any research particularly on research that involve human participants. As such, ethics in research are focused on what could be ethically proper and unacceptable when involved with participants (Schumacher & McMillan, 2010). To address the issues of ethics, we sought and obtained ethical certificate body and requested permission to conduct the study from DBE (2011) and was granted. Participating learners were requested to complete the assent and informed consent. Hence, their biographical data (see **Table 1**) is provided. Moreover, learners were given pseudonyms names, as follows: learner (L) were named L001 to L008 in order to protect their identities and to strengthen the anonymity and confidentiality.

Data Collection

To respond to the research questions, data were collected in two ways: classroom observations, and documents review. Therefore, we will present when and how each instrument was used to collect the data.

Classroom observations

This study adopted the participant observations; which gives the researcher a chance to look at and engage in some of the activities at the research site they observe (Creswell, 2014). Therefore, the first author was the participant observer in all the sessions of this study, engaged in the lesson and moved around the classroom. The classroom observations took place on two classroom sessions, and during these observations there were three combined predetermined aspects that we sought to focus on. These aspects focused on the learners' held IK, their knowledge construction and their ability to engage in learner interaction. These three aspects contributed towards responding to each of the three research questions.

Documents review

Bowen (2009) remarked that the researcher should collect and interpret documents to give expressions and meaning to the topic of interest. Creswell (2014) alludes that document review channels the researcher to be in par with the language and words of the participants, who have considered their written work. The documents which were reviewed where in the form of learners' activities which they wrote in groups as they were following the two teaching methods namely; jigsaw and De Bono's six thinking hats. This section of data collection was intended to answer the three research questions.

Data Analysis

Stake (1995) refers to data analysis as a meaning-making process in which researchers break down information and experiences into constituent elements and give them importance. In addition, Stake (1995) proposes that case study researchers choose between categorical aggregation and direct interpretation when analyzing data, while Creswell (2007) emphasized that in category aggregation, the researcher looks for several instances or patterns in the data to draw significant conclusions. In contrast, in direct interpretation, the researchers look for a single incident and draws conclusions from it. As a result, we used category aggregation as well as inductive approach, which we used to examine the textual material from all two data sets. We examined all of the data sets for similarities and differences before categorizing them and deducing relevant meanings and after the data was analyzed the findings were then interpreted through social constructivism as a lens.

RESULTS

In this section we present the data collected using the instruments previously deliberated upon. We begin with data collected during the first session (day 1), followed by data collected during the second session both through participative classroom observation and documents review (class activities). The topics taught on day 1 session was Biosphere to Ecosystems specifically Biomes (see DBE, 2011, p. 33).

Presentation and Analysis of Data Collected From the First Session (Day 1)

In this section we begin by presenting and deliberating on the findings drawn from classroom observations followed by activity done during the first session using the three main aspects namely; held IK, knowledge construction and learner interaction. Jigsaw teaching method was used, and **Table 2** is a representation of how the learners were grouped. Since only eight learners participated in this study; six girls and two boys. They were divided into two groups, each group having four learners: three girls and one boy. These groups were called home groups as per the requirement of jigsaw method. The groups were further divided into two to form expert groups. Therefore, the groups and learners were given names, as follows: group one as G1 and group two as G2; and learners (L) were named L001 to L008. As such, in the given activity, learners were expected to identify the name of the plant or animal, the biome(s) where it is found, and the traditional use of that plant or animal.

Table 2. Learner arrangements and topic allocation

Expert group	Topic
G1L001 and G2L008	Plant (sweat thorn)
G1L003 and G2L006	Plant (aloe)
G1L002 and G2L007	Animal (elephant)
G1L004 and G2L005	Animal (porcupine)

It is crucial to remember that the jigsaw method divides the class into two groups: home groups and expert groups. The class activity is then broken into smaller sections, with each expert group working on a different piece. Thus, the allocations are on **Table 3**. Later, expert groups split up, return to their home groups, and impart all of the knowledge they have gained to their peers.

Classroom observation

The observation schedule in **Table 3** stretches what was recorded during the classroom observations and will aid with the analysis.

Table 3 presented the records of what has transpired during classroom observations when learners were engaged in a jigsaw learning activity. Further deliberations follow.

Held IK, knowledge construction, and learner interaction: The majority of the learners do have IK related to some of the given plants and animals, and they were able to talk about and share that knowledge. This was evident when they were working on the Aloe ferox and Acacia karoo plant, wherein **G1L004** stated that

> "I can see the acacia karoo plant through the window"

Table 3. Observations recorded on the first session

Schedule of class	
Items	Comments
Held IK and sharing of it	- Learners do have IK related to the given plants and animals and are able to share it within their groups and to the class. - But they seem not to have any IK related to an elephant and cancer bush plant. They copy directly from the support material. I could not hear anyone giving any additional information related to this two items.
Knowledge construction and negotiation	- Learners use their own prior knowledge (held IK), ideas from their peers (in their groups and the class), their environment (learner L004 points the acacia karoo plant through the window, and the support material given to them to construct and negotiate the knowledge. - They are all engaged, giving information, and asking questions.
Learner communication and interaction	- Learners do work well together as a team/group. - They use both Sepedi and English to present their ideas. - They give each other a chance to talk and take turns to present their ideas; one learner speaking at a time. - They listen to one another and show respect. - They are able to ask questions and give each other a feedback.

Table 4. Document analysis tool: Jigsaw learning activity

Items	Yes	No	Other comments
Were learners able to identify and provide the names for			
All the given plants	X		Provided common English names, vernacular, and scientific names
All the given animals	X		Provided common English names, vernacular, and scientific names
The biome(s) in which the plants/ animal may be found	X		
Were learners able to provide the traditional uses of			
All the given plants	X		They have included the modern use of the *aloe ferox*
All the given animals	X		

and other learners looked through the window to confirm. They were also able to talk a lot about porcupine and springbok as **G1L001** stated that

> "porcupine's spike (barb) can be used to heal an inflamed skin and swollen skin,"

some of the learners (**G1L002**, **G2L006**, and **G2L008**) were curious to know how the thorn worked . Although **G1L001** was not able to explain what healing properties the thorn possesses, she proceeded to say,

> "by poking the affected area with the spike, the inflamed or swollen area you will recover after some time."

The extract show that the learners were working together, doing one thing at the same time; none seemed to be disengaged. They could construct and negotiate knowledge through active interactions with each other and the material given to them. They were talking and even asking for clarity from their peers and the teacher until they reached a common understanding and wrote down their conclusions and by so doing, learning was improved. Hence, learning could be improved when it is contextualized by relevant and authentic IK and it would help learners understand how science has always been a part of their lives since the time of their forefathers and how it connects them to their history and culture (Diwu & Ogunniyi, 2012; Pawilen, 2021)

Documents review

The learners were requested to provide the scientific names, biomes they were found and the traditional uses of the following organisms; a sweat thorn, aloe, elephant, and a porcupine. Table 4 was developed in order to aid with the analysis of the learners responses.

From the contents of Table 4, it is evident that learners were able to identify and provide names and the biomes from which the given plants and animals may be found. Learners were also able to provide the traditional uses of both the plants and the animals. Further deliberations are made below.

Sweat thorn: The two groups, through their experts, were able to write the name of the plant, the biome is found and were also able to provide different uses of the plant.

G1L004 wrote

> "this is a sweat thorn also known as acacia karoo and they are found in Savanna"

and **G2L008** wrote

> "the plant can also be found in grassland."

Such responses provided by the learners showed that the learners knew both the scientific name of the plant and where the plant can be found (van Wyk & Gericke, 2018). Where the learners were required to provide the uses of the plant, **G1L003** wrote

> "you can drink water of the boiled or soaked bark for fever,"

while **G2L006** said

> "the smoke of the plant can help treat headache and eye problems. We can also use the plant to make firewood."

The learners have correctly highlighted the plant's medicinal uses for both humans and animals, and on traditional technology and from this point is evident that their views agree with those of Dingaan and du Preez (2017) who alluded that acacia karroo has many socio-economic benefits for most of the South Africans. These sentiments are also shared by van Wyk and Gericke (2018), where they stated that the plant can be used as firewood, it produces edible gum, leaves and bark used in traditional medicines and found to treat diarrhea among others.

Aloe: The learners were also able to provide both the common and the scientific name of the plant and the biome which it is found.

G1L003 wrote

> "Aloe is the common name for the plant and the scientific name is aloe ferox,"

and **G2L006** wrote

> "this plant can be found in Savanna, Succulent Karoo, and grassland."

These responses resonate with what van Wyk and Gericke (2018) highlighted in their People's plants where they stated that the plant is also known as asphodelaceae, which is an attractive succulent found near Swellendam in the Cape Central to KwaZulu Natal. When the learners were requested to provide the plant's uses, **G1L002** wrote

> "mothers use it to stop their babies from breastfeeding by rubbing the bitter gel cut-off leaf on their nipples and the bitter taste will stop the baby from breastfeeding."

G2L008 wrote

> "you can apply it to ringworm to stop them from itching and spreading and can be boiled and be drunk to relieve constipation as well as being applied to wounds and bleeding gums."

The learners' responses show that they are well versed with this plant. It is interesting that their knowledge of how mothers stop their children from breastfeeding is also apparent in the Senol et al. (2023) study. Moreover, learners have mentioned the value of this plant gel for healing and as a cosmetic. Their views are in parallel with those who applaud the anti-inflammatory and hydrating properties of this gel (O'Brien et al., 2011). The ability of the plant to relieve constipation is due to its laxative effect which stems from the anthraquinones of which aloin is the main ingredient (Van Wyk et al., 1995; Chen et al., 2002).

G2L005 wrote

> "mixed with vaseline and apply it on the body to prevent sunburn, on the hair to prevent natural hair damage in winter".

This response resonates with Wyk and Gericke (2018) who argue that mixed with petroleum jelly, the plant can be applied to herps and shingles. These responses reflect the learners' knowledge of the plant's uses.

Elephant: The learners were able to provide both the common and the scientific names of the animal and state where the animal was found.

G2L006 wrote

> "the animal's common name is elephant, and its scientific name is Loxodonta Africana the animal is found in Savanna, grassland, and Thicket."

In a question that requested the learners to write about the use of an elephant.

G1L004 wrote

> "inhaling the smoke of burned dungs heal headaches, toothaches, nose bleeds and unblocks sinuses."

The learners managed to identify the animal, by providing the common English name and a scientific name. They also listed the biomes in which it may be found, as well as its traditional uses. Learners made most reference to the traditional use of only one item, which is dung, and did not mention other parts and their uses. As such this reflects the learners' knowledge and understanding of animals and plants. This is drawn from their ability to provide the scientific, common English and vernacular name of both the plant and animal. Hence, indigenous societies have their own applied sciences that they have used to deal with the situations that they encounter in their daily lives. However, the majority of such sciences are not recorded in writing in reading materials or textbooks (Anazifa & Hadi, 2017; Shehu, 2020), since they are passed down orally from generation to generation (Handayani, 2018).

Porcupine: The learners were also able to provide both the common and scientific names of the animal, as well as the biomes can be found.

G1L003 wrote

> "the common name of the animal is a porcupine, and its scientific name is Hystrix Africa Australis and can be found in the Savanna, deserts, grassland, and the forest."

G1L004 wrote

> "it's spine prevents nose bleeds, while its dried and crushed intestines are used to treat stomach-ache and their quills are used as ornaments and talismans."

G2L006 wrote

> "traditional healers use them to enhance their strengths and protection against enemies."

The learners managed to identify the animal; they gave it a vernacular, English, and scientific name. They allocated it to four biomes and listed its traditional uses. Amongst other uses, learners linked this animal to protection against enemies, evil spirits, and witchcraft, which shows metaphysical purposes. This disclosure was also reported by Neiman et al. (2019). Interestingly, Cronje et al. (2015) point out that aspects like these should not be overlooked in science classrooms; instead, a holistic approach to IK should be adopted in such instances.

Table 5. Learner arrangements during De Bono's six thinking hats activity

G1	G2
L001	L005
L002	L006
L003	L007
L004	L008

Presentation and Analysis of Data Collected During the Second Session (Day 2)

In this section we begin by presenting and deliberating on the findings drawn from classroom observations followed by activity done during the second session using the three main aspects namely; held IK, knowledge construction and learner interaction. De Bono's six thinking hats teaching method was used, and the following **Table 5** is a representation of how the learners were grouped. Since only eight learners participated in this study; six girls and two boys. In this session, learners were divided into two groups, each group having four learners: three girls and one boy. The topics taught on day 2 session was application of IK systems specifically traditional medicines and healers, Immunity, including "plants and animals' immune responses of against the infecting microorganism, vaccinations" (see Mc Knight, 2015, p. 23).

In the second session, learners were in groups, and the lesson was presented to the whole class based on the diseases that affect the skeleton, their causes, and their treatments: arthritis, rickets, and osteoporosis. We presented that arthritis can be treated in both Western and traditional ways. Either by using Western medicines such as Devil's claw (harpagophytum procumbens) capsules, aspirin, or cortisone drugs. Therefore, learners were given an activity with the aim of allowing learners to brainstorm and state their views and experiences with regard to the use of traditional and Western medicines, whether the two are conflicting or can coexist.

Classroom observation

Table 6 stress out what was recorded on the observation schedule:

(1) knowledge exhibition,

(2) knowledge construction and negotiation, and

(3) learner communication and interaction.

Table 6 presents the records of what has transpired during classroom observations when learners were engaged in a De Bono's six thinking hats learning activity.

At the time, we also heard one learner explaining what she used for period pains, and we captured the conversation, such an exhibition of knowledge allowed learners to organize their thinking, discuss their opinions, and come to conclusions. For example, learner **G1L002** explained to the group how she used traditional knowledge to treat period pains. She said,

> "I use leg/feet of a partridge bird, I boil it and drink the water in the morning and evening, dry it in the sun and will boil it again next time."

According to Mandikonza (2019), the integration of IK in classrooms will enable the use of components of learners' IK as a starting point to help learners understand subject concepts described in the curriculum. Hence, this invited all the learners to share their experiences, of which learner **G1L001** shared a different view to highlight that traditional knowledge did not work out for her hence she is in favor of the western knowledge. She said,

> "I used this other plant called marepetlana for tonsils, I was told to crush the plant, boil, and drink its tea, and then I would be healed in two

Table 6. Observation schedule: De Bono's six thinking hats activity

Schedule of class	
Items	Comments
Knowledge exhibition	- Learners do have knowledge about both the traditional medicines and the western medicines. - I can hear them explaining their experiences to their group mates. They ask each other questions, and feedback is provided. - For instance, **G1L002** explains to the group what she has used to treat period pains. - From their conversations, they highlight that they get this knowledge of traditional medicines from the elderly at home.
Knowledge construction and negotiation	- The color of the hat directs interactions amongst the learners. - All learners are actively involved, and they reflect on their lived experiences and what they observe around them, to construct and negotiate the knowledge within their groups. - Learners share with their group mates what they have used to treat various ailments. - Drawing from their conversations, some learners were in favor of traditional medicines while some were in favor of western medicines.
Learner communication and interaction	- Good communication skills are evident here; learners give each other a chance to express themselves, they show respect and listen to their peers when they talk. - They are able to ask one another questions and provides feedback. - They use both Sepedi and English to express themselves.

Table 7. Document analysis tool: De Bono's six thinking hats learning activity

Items	Yes	No	Other comments
Do learners have any experience with either traditional medicines or western medicines?	X		
Are learners able to reflect on their experiences?	X		
Were learners able to provide their perspectives as required by each hat	X		
White hat	X		
Red hat	X		Learners gave reasons to justify or explain their feelings which was not necessary.
Yellow hat	X		
Black hat	X		
Green hat	X		
Blue hat	X		

days, but it never healed me. I then went to buy calpol, tonzolyt pills and strepsils and I became better and healed in 3 days. That is why even today I would still go for western medicine".

It is interesting to note that every learner participated fully in the conversation and shared various remedies for different ailments.

The above responses exhibit informed views from the learners because they are able to clearly articulate their lived experiences with either traditional or western medicines. Learners also used their home language (Sepedi) to aid in the presentation of the processes and procedures involved. It is also evident that the elderly play an important role as IK holders in our communities, ensuring the generational transfer of knowledge. Such an exhibition of knowledge allowed learners to organize their thinking, discuss their opinions, and come to conclusions.

Documents review

Table 7 was developed in order to aid with the analysis of the learners' responses. From its contents, it is evident that learners understood the requirements of each hat, hence they were able to articulate their views with regard to the use of western and traditional medicines.

The white hat (facts): G1 wrote

"most people in South Africa prefer to use traditional medicines than western medicines because they believe that traditional medicine is more efficient, accessible, and affordable and does not require them to travel to clinics, hospitals and pharmacies to get medicine."

G2 wrote

"there are many traditional healers in each community in South Africa and this encourages many black people to trust traditional healers when they are sick, even after coming from the clinic and doctors they would still go and consult seeking traditional medicine."

This hat called learners to discover the facts about traditional and western medicines, but their views are more sided toward traditional medicines. Both groups hold that the use of traditional medicines dominates our South African communities. Therefore, their views and reasoning agree with those of Ndlovu (2016), Neiman et al. (2019), and Sobiecki (2014). Group two highlights that people pair traditional and western medicines. On that note, Mbongwa (2018) and Mahwasane et al. (2013) assert that people have always relied on traditional medicines for years, and so they believe some conditions need both western and traditional treatments.

The red hat (feelings, no reasons are given): G1 wrote

"in support of western medicines because they are more effective. They can cure the disease in the time they have prescribed on the bottle of the medicine and because we do not believe in Sangomas that is why we prefer western medicines. we feel that traditional medicines are not safe to use."

G2 wrote

"we are in support of traditional medicines because they are cheap and easy to get, and they can be used now and then."

Learners were supposed to express their emotions, feelings, or intuition about traditional and western medicines with no justifications. Therefore, by looking at their views, some have used the word "in support of" to show approval of either traditional or western medicines. While some have made their feelings very clear, all the groups have attached reasoning to their feelings.

The yellow hat (benefits, logical reasons are given): G1 wrote

> "indigenous medicines are cheap and easier to get than the prescribed western medicines but both of them are helpful and can work, it depends on which one you like and can afford."

G2 wrote

> "both indigenous medicines and traditional medicines work. It depends on which one you love, and it is your right to choose the one you favor."

Learners view both traditional and western medicines as being good for those who choose to use them. They focus on the issues of human rights, personal preference, and costs. Hence, researchers suggest that by bridging the gap between science and IK, we celebrate both the commonalities and the uniqueness of each knowledge domain and therefore give IK a place in the school science curriculum (de Beer, 2019; Zinyeka et al., 2016).

The black hat (cautions, logical reasons are given): G1 wrote

> "most of the traditional medicines are not scientifically tested and others say they are bad (bad taste), unlike western medicines which are tested, approved, and used worldwide."

G2 wrote

> "may lead to extinction of some plants because anyone can just pick the plants from the surrounding area as they are not protected and there are no laws to control the process. That is why we see people on the roads and taxi ranks selling different ready-made traditional medicines and dried herbs."

This required learners to expose the weaknesses associated with both traditional and western medicines. Therefore, both groups argue that most traditional medicines, unlike western ones, are not scientifically tested, and some threaten human life. de Beer and Whitlock (2009) are also of the view that some traditional healing practices are unsound.

The green hat (solutions to black hat problems, creativity): G1 wrote

> "indigenous medicines should be tested and proven to be safe to consume and people should only consult to the registered traditional healers and stop taking the medicines from anyone else, especially the ready-made ones."

G2 wrote

> "they can investigate and test different plants in laboratories to check if they are suitable to cure a particular disease and check other benefits of that plant, as well as risks but this does not mean we should undermine the traditional medicines."

Learners have provided solutions to the problems listed under the black hat. They suggest that traditional medicines should be tested, and that people should be vigilant against fake healers.

The blue hat (overview, thinking holistically, planning for an action): G1 wrote

> "since many South Africans prefer and use traditional medicines, especially in rural areas because they are cheap since they have plants and animals that they need to use near them."

G2 wrote

> "traditional healers are recognized in South Africa because they register them, and this shows that their knowledge and work is not bad because It has been used many years ago before we had western medicines."

Learners conclude that traditional and western medicines can co-exist. They suggest that elders, traditional healers, doctors, scientists, and researchers should cooperate and enrich each other for the benefit of all people. Such an approach is said to be empowering, and it creates respect for the veracity of traditional medicines globally (de Beer & Van Wyk, 2021).

DISCUSSION

Under this section, we deliberate on the findings of this study as well as the conclusions. We; begin with the findings to determine if the research questions were answered, followed by the interpretation of the findings through social constructivism and conclude with conclusions.

The Findings

What are grade 10 life sciences learners' views on the integration of IK on IK-related topics?

This study found that integrating IK in life sciences lessons allow learners to express themselves and see the connection between the subject content and their IK, as well as their context. Learners are of the view that the endeavor

(1) enhanced their comprehension and learning of life sciences and

(2) allowed them to conceptualize IK and its overall significance.

These findings declared a similar view and affirmed with those in Jacobs (2015) study that integration of IK enabled them to connect their lived experiences with life sciences concepts as well as Keane (2017). However, Mothwa's (2017) findings reported that there are a variety of IK in science classrooms and at times it may be difficult to know which one to use.

How does cooperative learning approach influence the integration of IK in grade 10 life sciences classroom?

This study found that the cooperative learning approach competently brought out the IK that is present in the life sciences classroom. Furthermore, because of the learning communities (groups) that were formed in the classroom. The findings revealed that a cooperative learning approach does not only enhance the integration of IK in life sciences classrooms but also the development of social and interpersonal skills. Such findings validates Evangelou (2023), Manyike and Shava, (2018), and Shehu (2020) assertions that this approach gives learners' platform to actively express themselves and their prior knowledge, interests, and needs in the learning context. Lastly, this study recognizes that deploying jigsaw and De Bono's six thinking hats methods to integrate IK in life sciences classes has a number of impediments that should be considered, namely; firstly, these methods require more time and effort to prepare for and complete the learning task. Secondly, learners face difficulties when they lack prior information on the topic of interest. Thirdly, cooperative learning approach promotes common understanding and learning, but there is still a risk that, if not identified and addressed, a misinterpreted idea from one group could spread to the entire class.

How relevant is the IK held by learners for integration into life sciences?

This study found that grade 10 life sciences learners possess distinct IK connected to life sciences topics. Learners articulated, verbally and in writing, their IK for every topic they encountered in this study. This shows that learners do, in fact, come to class with important knowledge (IK) that they can link to the life sciences topics and share during the learning process. As such, this discovery agrees with the argument that life sciences learners carry with them special IK that should be used for the teaching and learning of life sciences topics (de Beer, 2019; Reddy, 2019). This study also revealed that there is a link between life sciences content and grade 10 learners' IK. From the document analysis and learners discussions during observations, it is noted that learners could articulate and connect their IK to the life sciences topics considered in this study. Hence, Ronoh (2017) added items like agricultural and environmental aspects, food production, indigenous and endemic species, sustainable use of the environment, and natural resources.

Interpreting the Findings Through Social Constructivism

Culture

Culture refers to all the information, beliefs, attitudes, behaviors, and values shared by society (Idang, 2015). Therefore, the following items from the observations were considered under culture: IK by learners, knowledge construction and learner interaction. As such, consideration of culture enabled learners to be more comfortable sharing what they know, their IK, and their practices from various backgrounds about the given plants and animals. They used both Sepedi (their home language) and English (the language of teaching and learning) to facilitate the construction, communication, and transmission of what they knew, both in dialogue and in writing. Moreover, learners' use of the written and spoken language that they can all understand brought about good collaboration, communication, interactions, and understanding amongst them.

Language

Language refers to written or spoken symbols that serve as the foundation for thinking, reasoning, and comprehension (Vygotsky, 1962). It is a medium through which culture and communication are transmitted through social interactions. Therefore, the following items from observations were marked under language: knowledge construction and learner interaction. As observed, learners were working in groups to converse and make sense of what was given to them. Therefore, the use of written and spoken language that all learners understood allowed knowledge construction, and learner interaction. Both Sepedi (their home language) and English (the language of teaching and learning) were used to facilitate the construction, communication, and transmission of knowledge in dialogue and in writing amongst the groups. This brought about good collaboration, communication, interactions, and understanding amongst the learners.

CONCLUSIONS

This study demonstrates the tremendous benefits of integrating IK into grade 10 life sciences classroom. The findings show that integrating IK allows learners to relate the subject matter to their personal contexts and experiences, which improves their comprehension. This relationship promotes an increased understanding of life sciences concepts and emphasizes the importance of IK in their classroom setting. However, consideration for similar studies that would target a larger number of grade 10 would help provide a bigger picture of what role the integration of IK can play in life sciences classroom.

Cooperative learning have proven to be helpful in fostering IK integration in the participants' classroom setting. In the context of the participants, group learning does not only allow for the expression and sharing of knowledge, but it also helps to build important social and interpersonal skills. However, it is critical to recognize the issues connected to both jigsaw and De Bono's six thinking hats, such as the time and work required for preparation and the possibility of propagating misconceptions if not addressed effectively. As such, curriculum designers should systematically integrate IK-related topics into the life sciences curriculum to close the gap between learners' experiences and the subject matter. Furthermore, endeavor to provide appropriate tools and training for teachers to properly implement IK into their teaching practices in similar context. Secondly, there should be consideration for an organization of large-scale seminars and training sessions for teachers about the benefits and ways of integrating IK and cooperative learning approaches. In addition, train teachers in the efficient use of methods such as jigsaw and De Bono's six thinking hats to guarantee that these strategies are successfully deployed.

Furthermore, the study reveals that learners bring important IK to the classroom that is relevant and easily integrated into life sciences concepts. This lends credence to the concept that integrating learners' IK might improve the teaching and learning experience by making the content more personal and meaningful particularly in context similar to the participants. Therefore, there should be encouragement towards the inclusion of IK specialists and community elders in the teaching process to offer real-world context and experiences that will enhance the learning environment.

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REFERENCES

Abah, J., Mashebe, P., & Denuga, D. (2015). Prospect of integrating African indigenous knowledge systems into the teaching of science in Africa. *American Journal of Educational Research, 3*(6), 668-673.

Alghamdi, H. H. (2018). Exploring second language vocabulary learning in ESL classes. *English Language Teaching, 12*(1), Article 78. https://doi.org/10.5539/elt.v12n1p78

Anazifa, D., & Hadi, R. F. (2017). The integration of Javanese indigenous knowledge in biology learning resources development. *Journal of Physics: Conference Series, 812*, Article 012057. https://doi.org/10.1088/1742-6596/812/1/012057

Animasahun, R. A. (2007). Measured effect of emotional intelligence education in the remediation of aggressive behaviours among the members othe NURTW in Ibadan Metropolis. *IFE PsychologIA, 15*(1). https://doi.org/10.4314/ifep.v15i1.23733

Balfour, R. J. (2019). Foreword. In J. de Beer (Ed.), *The decolonization of the curriculum project: The affordances of indigenous knowledge for self-directed learning*. AOSIS.

Baneng, M. (2020). Cooperative learning approach applying jigsaw strategy to enhance students' comprehension skill. *Journal of Physics: Conference Series, 1471*, Article 012027. https://doi.org/10.1088/1742-6596/1471/1/012027

Bhandari, B., Mehta, B., Mavai, M., Singh, Y. R., & Singhal, A. (2017). Jigsaw method: An innovative way of cooperative learning. *Indian Journal of Physiology and Pharmacology, 61*(3), 315-321.

Chen, B., & Wei, B. (2015). Examining chemistry teachers' use of curriculum materials: In view of teachers' pedagogical content knowledge. *Chemistry Education Research and Practice, 16*(2), 260-272. https://doi.org/10.1039/c4rp00237g

Chukwu, J. C., & Arokoyu, A. A. (2019). Effects of jigsaw-puzzle instructional strategy on secondary school students' performance on growth as a concept in biology in Abia State. *Advances in Research, 20*(1), 1-6. https://doi.org/10.9734/air/2019/v20i130148

Creswell, J. W. (2007). Five qualitative approaches to inquiry. In J. W Creswell (Ed.), *Qualitative inquiry and research design: Choosing among five approaches*. SAGE.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approach* (4th ed.). SAGE.

Cronje, A. (2015). *Epistemological border-crossing between western science and indigenous knowledge and its implications for teacher professional development* [Unpublished PhD thesis]. University of Johannesburg.

Cronje, A., de Beer, J., & Ankiewicz, P. (2015). The development and use of an instrument to investigate science teachers' views on indigenous knowledge. *African Journal of Research in Mathematics, Science and Technology Education, 19*(3), 319-332. https://doi.org/10.1080/10288457.2015.1108567

DBE. (2011). *Curriculum and assessment policy statement*. Pretoria. South Africa.

de Beer, J. (2015). *Crossing boundarised epistemologies in science education: The affordances of indigenous knowledge*. http://hdl.handle.net/10394/25843

de Beer, J. (2016). Re-imagining science education in South Africa: The affordances of indigenous knowledge for self-directed learning in the school curriculum. *Journal for New Generation Sciences, 14*(3), 34-46.

de Beer, J. (2019). The affordances of project-based learning and classroom action research in the teaching and learning of natural sciences. Perspectives in Education, 37(2), 67-79. https://doi.org/10.18820/2519593x/pie.v37i2.5

de Beer, J., & Van Wyk, B. E. (2016). Ethnobotanical and anthropological perspectives on the use of magic plants in traditional healing practices in South Africa. *Planta Medica, 81*(S 01), S1-S381. https://doi.org/10.1055/s-0036-1596444

de Beer, J., & Van Wyk, B-E. (2021). Indigenous knowledge systems and western science: The conundrum of validation. *Indilinga African Journal of Indigenous Knowledge Systems, 20*(2), 170-193.

de Beer, J., & Whitlock, E. (2009). Indigenous knowledge in the life sciences classroom: Put on your de Bono hats! *The American Biology Teacher, 71*(4), 209-216. https://doi.org/10.2307/27669414

Denhere, C., Chinyoka, K., & Mambeu, J. (2013). Vygotsky's zone of proximal development theory: What are its implications for mathematical teaching? *Greener Journal of Social Sciences, 3*(7), 371-377. https://doi.org/10.15580/gjss.2013.7.052213632

Dhull, P., & Verma, G. (2019). Jigsaw teaching technique for teaching science. *International Journal of Research and Analytical Reviews, 6*(2), 809-815.

Dingaan, M., & du Preez, P. J. (2018). Vachellia (acacia) karroo communities in South Africa: An overview. In L. Hufnagel (Ed.), *Pure and applied biogeography*. InTechOpen. https://doi.org/10.5772/intechopen.70456

Diwu, C. T., & Ogunniyi, M. B. (2012). Dialogical argumentation instruction as a catalytic agent for the integration of school science with indigenous knowledge systems. *African Journal of Research in Mathematics, Science and Technology Education, 16*(3), 333-347. https://doi.org/10.1080/10288457.2012.10740749

Easton, P. B. (2011). Hawks and baby chickens: Cultivating the sources of indigenous science education. *Cultural Studies of Science Education, 6*(3), 705-717. https://doi.org/10.1007/s11422-011-9344-4

Erinosho, S. (2013). Integrating indigenous science with school science for enhanced learning: A Nigerian example. *International Journal for Cross-Disciplinary Subjects in Education, 4*(2), 1137-1143. https://doi.org/10.20533/ijcdse.2042.6364.2013.0160

Etikan, I., Alkassim, R., & Abubakar, S. (2016). Comparision of snowball sampling and sequential sampling technique. *Biometrics and Biostatistics International Journal, 3*(1), Article 55. https://doi.org/10.15406/bbij.2016.03.00055

Evangelou, F. (2023). Teaching techniques for developing the learner-centred approach in the classroom. *European Journal of Education Studies, 10*(2), 166-192. https://doi.org/10.46827/ejes.v10i2.4667

Fakoyede, S. J., & Otulaja, F. S. (2019). Beads and beadwork as cultural artifacts used in mediating learners' agentic constructs in science classrooms: A case for place-based learning. *Cultural Studies of Science Education, 15*(1), 193-210. https://doi.org/10.1007/s11422-019-09911-4

Frambach, J. M., van der Vleuten, C. P., & Durning, S. J. (2013). AM last page. Quality criteria in qualitative and quantitative research. *Academic Medicine, 88*(4), Article 552.

Gillies, R. (2016). Cooperative learning: Review of research and practice. *Australian Journal of Teacher Education, 41*(3), 39-54. https://doi.org/10.14221/ajte.2016v41n3.3

Hammond, L. D., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2019). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97-140. https://doi.org/10.1080/10888691.2018.1537791

Han, J., Park, D., Shi, F., Chen, L., Hua, M., & Childs, P. R. (2019). Three driven approaches to combinational creativity: Problem-, similarity-and inspiration-driven. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 233*(2), 373-384. https://doi.org/10.1177/0954406217750189

Handayani, R. D., Wilujeng, I., & Prasetyo, Z. K. (2018). Elaborating indigenous knowledge in the science curriculum for the cultural sustainability. *Journal of Teacher Education for Sustainability, 20*(2), 74-88. https://doi.org/10.2478/jtes-2018-0016

Hani, U., Petrus, I., & Sitinjak, M. (2017). The effect of six thinking hats and critical thinking on speaking achievement. *Advances in Social Science, Education and Humanities Research, 82*, 85-88. https://doi.org/10.2991/conaplin-16.2017.18

Haradhan, K. M. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development, Environment and People, 7*(1), Article 23. https://doi.org/10.26458/jedep.v7i1.571

Havenga, H. M. (2015). *Engaging in indigenous knowledge technology: Conceptualisation and contextualisation in problem-based environments*. AOSIS Book.

Hewson, M. G., & Ogunniyi, M. B. (2010). Argumentation-teaching as a method to introduce indigenous knowledge into science classrooms: Opportunities and challenges. *Cultural Studies of Science Education, 6*(3), 679-692. https://doi.org/10.1007/s11422-010-9303-5

Idang, G. E. (2018). African culture and values. *Phronimon, 16*(2), 97-111. https://doi.org/10.25159/2413-3086/3820

Jacobs, K. R. (2015). *The classroom implementation of indigenous knowledge in the science curriculum by science teachers in the Western Cape Province, South Africa* [PhD thesis, University of Cape Town].

Jacobs, S., de Beer, J., & Petersen, N. (2019). The professional development of teachers in terms of their understanding, experience, and application of indigenous knowledge and cooperative learning in life sciences education. In *Proceedings from ISTE International Conference on Mathematics, Science and Technology Education: Towards Effective Teaching and Meaningful Learning in Mathematics, Science and Technology*.

Jautse, P. P., Thambe, N., & de Beer, J. (2016). A day at the museum: A case study of how museums could partner with universities in teacher education. In *Proceedings from ISTE International Conference on Mathematics, Science and Technology Education: Towards Effective Teaching and Meaningful Learning in Mathematics, Science and Technology*.

Johnson, D. W., & Johnson, R. T. (2014). *Joining together: Group theory and group skills*. Pearson.

Karacop, A., & Diken, E. H. (2017). The effects of jigsaw technique based on cooperative learning on prospective science teachers' science process skill. *Journal of Education and Practice, 8*(6), 86-97.

Kaya, M. F. (2013). The effect of six thinking hats on student success in teaching subjects related to sustainable development in geography classes. *Kuram ve Uygulamada Egitim Bilimleri, 13*(2), 1134-1139.

Keane, M. (2017). Why indigenous knowledge has a place in the school science curriculum. *The Conversation*. https://theconversation.com/why-indigenous-knowledge-has-a-place-in-the-school-science-curriculum-44378

Khupe, C. (2014). *Indigenous knowledge and school science: Possibilities for integration* [PhD thesis, University of Witwatersrand].

Knapp, C. E. (2014). *Place-based curriculum and pedagogical models: My adventures in teaching through community contexts*. Psychology Press.

Kwanya, T. (2015). Indigenous knowledge and socioeconomic development: Indigenous tourism in Kenya. In *Proceedings of the International Conference on Knowledge Management in Organizations*. https://doi.org/10.1007/978-3-319-21009-4_26

Mahwasane, S., Middleton, L., & Boaduo, N. (2013). An ethnobotanical survey of indigenous knowledge on medicinal plants used by the traditional healers of the Lwamondo Area, Limpopo Province, South Africa. *South African Journal of Botany, 88*, 69-75. https://doi.org/10.1016/j.sajb.2013.05.004

Mandikonza, C. (2019). Integrating indigenous knowledge practices as context and concepts for the learning of curriculum science: A methodological exploration. *Southern African Journal of Environmental Education, 35*(1). https://doi.org/10.4314/sajee.v35i1.13

Manyana, X. Y. (2020). *Exploring affordances and hindrances when indigenous knowledge is integrated with the topic of waves and sound in a grade 10 physical sciences township class* [Masters' thesis, Rhodes University].

Manyike, T. V., & Shava, S. (2018). The decolonial role of African indigenous languages and indigenous knowledges in formal education processes. Indilinga *African Journal of Indigenous Knowledge Systems, 17*(1), 36-52.

Mapedza, E., Rashirayi, T., Xueliang, C., Haile, A. T., van Koppen, B., Ndiyoi, M., & Sellamuttu, S. S. (2022). Indigenous knowledge systems for the management of the Barotse flood plain in Zambia and their implications for policy and practice in the developing world. In *Current directions in water scarcity research* (Vol. 4, pp. 209-225). Elsevier. https://doi.org/10.1016/B978-0-12-824538-5.00011-X

Mawere, M. (2015). Indigenous knowledge and public education in sub-Saharan Africa. *Africa Spectrum, 50*(2), 57-71. https://doi.org/10.1177/000203971505000203

Mc Knight, M. (2015). *Teachers' experiences of indigenous knowledge systems (IKS) found in the life sciences curriculum: A case study of life sciences teachers at a high school in the Pinetown District* [Master's thesis, University of KwaZulu-Natal].

McLeod, S. (2018). Constructivism as a theory for teaching and learning. *Simply Psychology*.

https://www.simplypsychology.org/constructivism.html

McMillan, J. H., & Schumacher, S. (2010). *Research in education: Evidence-based inquiry, my education lab series*. Pearson.

Mothwa, M. M. (2011). *Teachers' experiences of incorporating indigenous knowledge in the life sciences classroom* [Master's thesis, University of Johannesburg].

Murye, A. F., & Pelser, A. J. (2018). *Commercial harvesting of marula (sclerocarya birrea) in Swaziland: A quest for sustainability*. IntechOpen. https://doi.org/10.5772/intechopen.76606

Ndlovu, H. L. (2016). The role of traditional healers in hiv prevention in southern african society: The case of Eswatini. *Open Journal Systems, 5*(1), 21-31.

Nicholas, G. (2018). It's taken thousands of years, but Western science is finally catching up to traditional knowledge. *The Conversation*. https://theconversation.com/its-taken-thousands-of-years-but-western-science-is-finally-catching-up-to-traditional-knowledge-90291

Nie, W. W., & Aziz, A. A. (2019). Utilizing De Bono's red, yellow and green thinking hats technique in answering hots-based comprehension questions. In *Proceedings of the International Conference on Multidisciplinary Research in Social Sciences and Engineering* (pp. 128-139).

Nieman, W. A., Leslie, A. J., & Wilkinson, A. (2019). Traditional medicinal animal use by Xhosa and Sotho communities in the Western Cape Province, South Africa. *Journal of Ethnobiology and Ethnomedicine, 15*, Article 34. https://doi.org/10.1186/s13002-019-0311-6

Nurbianta, N., & Dahlia, H. (2018). The effectiveness of jigsaw method in improving students reading comprehension. *English Teaching Journal, 9*(1), 70-86. https://doi.org/10.26877/eternal.v9i1.2416

Nyang, A., Adesina, F., & Osman Elasha, B. (2007). The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change, 12*(5), 787-797. https://doi.org/10.1007/s11027-007-9099-0

O'Brien, C., Van Wyk, B. E., & Van Heerden, F. (2011). Physical and chemical characteristics of aloe ferox leaf gel. *South African Journal of Botany, 77*(4), 988-995. https://doi.org/10.1016/j.sajb.2011.08.004

Odora Hoppers, C. (2021). Research on indigenous knowledge systems: The search for cognitive justice. *International Journal of Lifelong Education, 40*(4), 310-327. https://doi.org/10.1080/02601370.2021.1966109

Ojekwu, I. N., & Ogunleye, B. O. (2020). Effects of jigsaw learning strategy on science students' performance and interest in biology in selected schools in rivers state, nigeria. *Sapientia Foundation Journal of Education, Sciences and Gender Studies, 2*(3), 325-334.

Oliveira, B. R. M., Vailati, A. L., Luiz, E., Böll, F. G., & Mendes, S. R. (2019). Jigsaw: Using cooperative learning in teaching organic functions. *Journal of Chemical Education, 96*(7), 1515-1518. https://doi.org/10.1021/acs.jchemed.8b00765

Onwu, G. O. M., & Mufundirwa, C. (2020). A two-eyed seeing context-based approach for incorporating indigenous knowledge into school science teaching. *African Journal of Research in Mathematics, Science and Technology Education, 24*(2), 229-240. https://doi.org/10.1080/18117295.2020.1816700

Òtúlàjà, F. S., Cameron, A., & Msimanga, A. (2011). Rethinking argumentation-teaching strategies and indigenous knowledge in South African science classrooms. *Cultural Studies of Science Education, 6*, 693-703. https://doi.org/10.1007/s11422-011-9351-5

Pateşan, M., Balagiu, A., & Zechia, D. (2016). The benefits of cooperative learning. In *Proceedings of the International Conference Knowledge-Based Organization* (pp. 478-483). https://doi.org/10.1515/kbo-2016-0082

Pawilen G, T. (2021). Integrating indigenous knowledge in the philippine elementary science curriculum. *International Journal of Curriculum and Instruction, 13*(2), 1148-1160.

Pretorious, E., de Beer, J., & Lautenbasch,G. (2014). Professional development of science teachers: The A-team hybrid ecology of learning practice. In *Proceedings of the International Conference on Mathematics, Science and Technology Education: Towards Effective Teaching and Meaningful Learning in Mathematics, Science and Technology* (pp. 553-566).

Rahmawati, Y., & Ridwan, A. (2017). Empowering students' chemistry learning: The integration of ethnochemistry in culturally responsive teaching. *Bulgarian Journal of Science Education, 26*(6), 813- 830.

Rankoana, S. A. (2017). The use of indigenous knowledge in subsistence farming: Implications for sustainable agricultural production in Dikgale community in Limpopo Province, South Africa. *Towards Sustainable Agriculture: Farming Practices and Water Use: Frontiers in Sustainability Series, 1*(1), 63-74. https://doi.org/10.3390/books978-3-03842-331-7-4

Reddy, C. (2019). *The integration of Indian indigenous knowledge into the SA life science curriculum* [PhD thesis, North-West University].

Ronoh, J. C. (2017). *Indigenous knowledge in the school curriculum: Teacher educator perceptions of place and position* [Master's thesis, Nelson Mandela University].

Roseth, C. J., Lee, Y. K., & Saltarelli, W. A. (2019). Reconsidering jigsaw social psychology: Longitudinal effects on social interdependence, sociocognitive conflict regulation, motivation, and achievement. *Journal of Educational Psychology, 111*(1), 149-169. https://doi.org/10.1037/edu0000257

Sabbah, S. (2016). The effect of jigsaw strategy on ESL students' reading achievement. *Arab World English Journal, 7*(1), 445-458. https://doi.org/10.24093/awej/vol7no1.27

Sebotsa, T. (2020). *Teachers' lived experiences of contextualised interventions, and its affordances for their professional development and for self-directed learning in physical sciences* [PhD thesis, North-West University].

Senanayake, S. G. J. N. (2006). Indigenous knowledge as a key to sustainable development. *Journal of Agricultural Sciences–Sri Lanka, 2*(1), 87-94. https://doi.org/10.4038/jas.v2i1.8117

Şenol, E., Ercan, A., & Karatekİn, E. (2023). Weaning reasons, practices and total duration of breastfeeding in physician mothers. *Namık Kemal Tıp Dergisi, 11*(2), 133-138. https://doi.org/10.4274/nkmj.galenos.2023.85520

Shehu, A. (2021). Western education versus indigenous knowledge of the Tarok in Plateau State, Nigeria. *Information Impact: Journal of Information and Knowledge Management, 11*(4), 59-68. https://doi.org/10.4314/iijikm.v11i4.6

Shi, W., & Han, L. (2019). Promoting learner aAutonomy through cooperative learning. *English Language Teaching, 12*(8), 30-36. https://doi.org/10.5539/elt.v12n8p30

Sobiecki, J. (2014). The intersection of culture and science in South African traditional medicine. *Indo-Pacific Journal of Phenomenology, 14*(1). https://doi.org/10.2989/IPJP.2014.14.1.6.1238

Stake, R. (1995). *The art of case study research*. SAGE.

Ugwu, A. N., & Diovu, C. I. (2016). Integration of indigenous knowledge and practices into chemistry teaching and students' academic achievement. *International Journal of Academic Research and Reflection, 4*(4), 22-30.

Van Wyk, B. E., & Gericke, N. (2018). *People's plants: A guide to useful plants of Southern Africa*. Briza Publications.

Van Wyk, B. E., Yenesew, A., & Dagne, E. (1995). Chemotaxonomic significance of anthraquinones in the roots of asphodeloideae (asphodelaceae). *Biochemical Systematics and Ecology, 23*(3), 277-281. https://doi.org/10.1016/0305-1978(94)00094-W

Van Wyk, G., & de Beer, J. (2019). Bridging the theory-practice divide: Life sciences student teachers' perceptions of teaching in communities of practice at a teaching school. *African Journal of Research in Mathematics, Science and Technology Education, 23*(3), 276-285. https://doi.org/10.1080/18117295.2019.1658454

Vygotsky, L. S. (1962). *Thought and language*. MIT Press. https://doi.org/10.1037/11193-000

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Vygotsky, L. S. (1987). Thinking and speech. The collected work of Vygotsky. *Problems Of General Psychology, 1*, 39-285.

Zidny, R., & Eilks, I. (2018). Indigenous knowledge as a socio-cultural context of science to promote transformative education for sustainable development: A case study on the Baduy Community (Indonesia). In I. Eilks, S. Markic, & B. Ralle (Eds.), *Building bridges across disciplines for transformative education and a sustainable future* (pp. 249-256). Shaker.

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education, 29*(1), 145-185. https://doi.org/10.1007/s11191-019-00100-x

Zinyeka, G., Onwu, G. O., & Braun, M. (2016). A truth-based epistemological framework for supporting teachers in integrating indigenous knowledge into science teaching. *African Journal of Research in Mathematics, Science and Technology Education, 20*(3), 256-266. https://doi.org/10.1080/18117295.2016.1239963