PEDAGOGICAL MODEL FOR DECOLONISING, INDIGENISING AND TRANSFORMING SCIENCE EDUCATION CURRICULA: A CASE OF SOUTH AFRICA

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Abstract. *In Africa, Science education curricula have been instrumental in promoting Western worldviews as being universal. An educational transformation and decolonisation of the school curriculum is required. A focus on an African worldview and an integration of the local context and community-based information is necessary for survival, i.e., Indigenous Knowledge System (IKS). While IKS is enshrined in the schooling curriculum, Educators experience challenges with implementing it, because the pedagogical strategies have not been clearly described. An in-depth qualitative study was conducted with the Indigenous Knowledge (IK) holders of the Zulu cultural group and Senior High School (SHS) Science teachers to explore how IK on environmental sustainability could be taught in South African science classrooms. The research employed an interpretivist, multi-site ethnographic, qualitative approach, and naturalistic research style. In-depth interviews were used to generate data from the purposively selected community persons. The thematically analysed findings were used to develop a culturally specific pedagogical model on how to teach IK in science classrooms: touring cultural places; demystifying indigenous practices and perception; utilizing indigenous pedagogies; teaching wisdom behind indigenous practices etc. The research recommends that future studies be conducted on applying the model in different geographical and cultural schooling contexts.*
Keywords: *context sensitive curricula, pedagogical strategies, South African curriculum, Western worldview*

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Introduction

In South Africa, since 1994 when democracy was gained, the curricula at the school and tertiary levels were revised to be inclusive of local community-based knowledge that is used by communities for their survival, Indigenous Knowledge. Indigenous Knowledge Systems (IKS), the system of knowledge that various societies developed before the introduction of modern science, is gaining greater recognition as policy, research, and teaching in the school and higher education levels. The national policy on the importance, the IKS policy of 2004 and the current schooling curriculum - Curriculum Assessment Policy Statements (CAPS) for Natural, Physical and Life Sciences recognizes the teaching of IKS in schools. Several higher education institutions have established IKS centres of excellence, notably – University of North West, University of KwaZulu Natal, University of Limpopo etc (DBE, 2011; DST, 2004; Kaya, 2013). These centres serve as hubs for the historical tracing and growth of IKS in research, teaching and community engagement. Recent debates on decolonizing and transforming science education in South Africa have traversed from the relevance of indigenous epistemologies in formal education curricula to 'how to teach' indigenous knowledge in schools and higher education institutions. Consequently, many scholarships advertising for ways to rethink the curriculum in both the schooling and higher education sectors (Chikoko, 2016; De Beer & Petersen, 2016; Gumbo, 2016a, 2016b; Philip Higgs, 2016; Kamwendo, 2016; Kaya & Seleti, 2014; Le Grange, 2016; Msila, 2016a, 2016b; Msila & Gumbo, 2016; Mudaly, 2018; Shava, 2016; Webb, 2016). The integration of IKS in science education is hoped to counter the Western-focused science content with contextually relevant knowledge from communities in Africa. The access to knowledge for learners is broadened and they can experience their contextual knowledge in the classroom settings (De Beer & Petersen, 2016; Phillip Higgs, 2016). Moreover, teacher education programmes are to be grounded in the philosophical foundations of the indigenous culture of the local community and not to privilege only westernised scientific knowledge (Aikenhead & Lima, 2009).

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Despite acknowledging the value of IK, most science educators hardly infuse IK in their teaching. Reasons given include less exposure to IK in pre-service teacher education; under-developed IK pedagogical content knowledge; inadequate understanding of the nature of science and IK; fear of teaching 'false science' (Cronje et al., 2015; De Beer & Petersen, 2016; De Beer & Whitlock, 2009; Mothwa, 2011; Msila & Gumbo, 2016; Ogunniyi, 2007). In the quest for Africanising, decolonization and transforming the educational system in South Africa, Le Grange (2002, p. 68) states "a more important concern I wish to raise here is the failure of higher education policies after apartheid to provide alternative frameworks for knowledge production to those provided by dominant Western knowledge system" In October 2015, the South African Minister of Higher Education and Training (HET) called for a central African focused (Africanization) of higher education and persuaded the institutions to shed off troubling aspect of apartheid, to instead work for the decolonisation of the education curriculum (Le Grange, 2016). The curriculum therefore was to be reconstructed and refashioned to reflect some of the African traditional and indigenous thoughts, ideas, epistemologies, ontologies and axiologies. This is also a global concern and a central problem for the 21st century. This research presents a construction of a pedagogical model for decolonising, indigenising and transforming science education curricula, as informed from the cultural perspectives of indigenous environmental sustainability (IES) IK-holders and science teachers. Govender et al. (2016, p. 182) argued that a 'scholarly encounter with IKS and IK holders could enhance the process and style with which academics 'conduct research and conceptualise education' as IK holders could tremendously contribute towards the policy formulation and implementation for addressing any gaps in moving from a solely western perspective to an integrated IKS and western perspective.

Purpose of the Research

The main purpose of this research was to explore and present a model for how indigenous environmental sustainability could be taught in the science education curricula, as viewed from the IK holders and Science teachers in South Africa and why they have the particular views on how to teach indigenous environmental sustainability. The research is to contribute knowledge to the scholarship on recent call for africanisation, decolonisation, indigenisation, and transformation of the science education curricula (DBE, 2011; DST, 2004).

Literature Review

Education in South Africa and IKS

Many scholars highlight the status of the Western worldview in African educational systems since colonial days to the democratic era. Castagno and Brayboy (2008) contended that Westernised science has no recognition for other bodies of knowledge like IK and indigenous ontologies. Shava (2016) asserts that the Southern African school agriculture syllabus is replete with foreign examples of fruit crops and captures insignificant examples of indigenous plants. Odora Hoppers (2006) added that the colonialists disregarded and devalued the African beliefs and practices. Anwar (2011) states that the colonialist colluded to eliminate African IK and made Westernised beliefs, practices and epistemologies predominate, thereby hegemonising black Africans formal education. Msila and Gumbo (2016) contended that many Africans were influenced by Western ideologies, knowledge and practices that they internalized to the disdain of their own beliefs and practices.

This is a major concern that calls for intensive scholarly research in African IKS. Furthermore, Msila and Gumbo (2016) assert that there has been deliberate and gross neglect of African cultures and IKS in curricula. Meanwhile, there are other ways of knowing by which students could explore their natural environment. For instance, the nature of science and IK share many principles in common (Cronje, 2015; Fortuin, 2017). In recent times, the contestation of denigration and subjugation of IK as well as issues of relevance of IK in school and higher education in the Republic of South Africa is gradually giving way for issues of how the teaching of IK could happen. But science educators and curriculum developers are confronted by various challenges in the quest to decolonise and indigenise the South African science education curricula (Opoku & James, 2020b). Msila and Gumbo (2016, p. 10) posited that in post-colonial Africa, education needs to be transformed through educational decolonisation and reconstruction, as "knowledge is transformed, reconstructed and rewritten to celebrate differences, diversity, pluralism, multiplicity and heterogeneity" without elevating one form of knowledge over another. Thus, the need for a pedagogy and curricula that reflect African epistemic experience, through reclamation of indigenous African epistemologies in curriculum is indispensable.

Models for Indigenising Education Curricula

In the quest for the educational transformation and sustainable Africanisation of the curricula, several models and or theories, approaches for indigenizing the education curricula have been proposed by some scholars:

Julius Nyerere's philosophical model on indigenising curriculum (Kadenyi & Kariuki, 2011; Kassam, 1994; Nasongo & Musungu, 2009); the Performance Partnership and Co-existence approach proposed by Turnbull (1997) and expounded on by Le Grange (2002) to include creation of the knowledge space for practicable coexistence of Western and African indigenous epistemologies in educational institutions; Adedeji (1981) Adaptation approach and expounded on by Mokhoba (1999) to include adapting to the values and needs of the specific society; the African Philosophy approach – renaissance of philosophies such as Afrocentricity, ubuntu, Africanism, African humanism (Bennaars, 1990, 1998; Luthuli, 1982; Palermo, 1997); the Curriculum Engineering approach (Cross, 2004; Shanyanana & Ndofirepi, 2015); the Separatist Development Approach (Le Grange, 2002); the Culture Product Indigenization Process Model; Mazrui seven pillars of wisdom and model for indigenising the university curriculum (Msila & Gumbo, 2016); the incorporationist, the separatist and the integrationist approaches to teaching IKS (Naidoo & Vithal, 2014).

Theoretical Constructs

In recent years, the inestimable value of African IKS in addressing current environmental and social crisis has been highlighted. For instance, Gyekye's 1997 cultural revivalism African philosophy that contends for renaissance of the hegemonised African indigenous practices and traditions is believed to be an essential tool for addressing current economic, sociopolitical and environmental challenges. African minds are to be purged from colonialist global north thought pattern (Ciaffa, 2008). However, cultural revivalism adherents have been criticised that their philosophy rather hinders advances in science and technology in that the perspectives are old and less potent to handling current African challenges (Famakinwa, 2012). Despite the criticism of cultural revivalism, several other scholars believe that African traditions have depths of intellectual knowledge relevant for African societies. Consequently, African epistemologies and cultural identity must be restored and re-appropriated considering that many Africans have been incapacitated socially, economically, intellectually, religiously, politically, technologically by the European colonialist. Africans are called upon to re-appropriate AIK (Dei, 2017; Hountondji, 2009; Kiti, 2013; Le Grange, 2016).

This study is in line with the critical ontological and indigenous knowledge theories which contends that when educators integrate IK into curriculum, it enhances learning and makes IK applicability very relevant to indigenous people. This assertion is premised on the fact that learning is socially and culturally contextualized; an approach that guides curriculum development in line with socio-cultural theories. Critical ontological theory contends against curricula that is bereft of IKS. Rather, it contends for the emancipation on indigeneity and renaissance of indigenous people's confidence (Choy & Woodlock, 2006; McLaughlin & Whatman, 2008; Michie, 1999, 2002). Nhalevilo-Afonso (2013) contended that it is imperative to look for legitimated theories to integrate IKS to remedy the practice of teaching IKS in science classrooms, which is already disconnected from its own socio-cultural context. Consequently, Nhalevilo-Afonso (2013) proposed a five stage subjective framework for interrogating the incorporation of IKS in African school curricula, in which Nhalevilo-Afonso "reflects on framework curriculum changes and programmes of research into cultural contextualization of science education and/or of IKS inclusion in school curricula".

The stages include colonisation ("the period when IK had no recognition" p. 25); Decolonization ("the period when awareness of the value of IK began to take centre stage in debates on curriculum policies" p. 26); Neo-colonialism ("new kind of colonialism that undermine the cultural values through teaching IKS in a decontextualized, expropriated and objectified manner" p. 27); Re-birth ("this interrogates the lenses through which IKS is communicated and the interest being served by specific IKS content and pedagogies and the way in which IKS" p. 29); and Theorization ("the stage that aims to address ontological, axiological, and epistemological issues for including IKS in school curricula" p. 31). In theorizing, Nhalevilo-Afonso (2013) posited that the crucial question for interrogation in the theorisation stage is "How do we teach that knowledge – IKS". The theorization stage question, according to Nhalevilo-Afonso (2013, p. 31) "represents a particular and very important challenge for Africa", one great challenge being the "gap that might exist between theory and practice" (p. 32). The current research is situated in the Postcolonial theory which advocates for culturally relevant and practicable curricula in parts of the world that experienced

colonialism, like South Africa. The Postcolonial theory contends against the superimposition of Western ideologies and practices that denigrate indigenous beliefs, cultures and practices (as subjugated knowledge, irrelevant and unproven). The (African) philosophical perspectives discussed above undoubtedly 'influence the philosophy, direction, content, and pedagogy that undergird education systems' (Mudaly, 2018, p. 51) and weaves well into the social reconstructionist theory which contends against social inequality in educational curricular. Moreover, adherents of the social reconstructionist theory perceive cultural factors to strongly frame human experiences and therefore calls for a re-thinking of all facets of curriculum development and relevant pedagogical strategies such as instructional planning, evaluation and methodologies to be employed (Schiro, 2015).

Research Methodology

Research Design

This research utilized a qualitative research approach, and an ethnographic naturalistic research style, located within the interpretivist paradigm. The research explored the views of the Zulu (South African) IK holders and Science Educators on how to teach Indigenous Environmental Sustainability (IES) in formal educational institutions and why they have these views. The research results were used to present a model of how to teach it. Creswell (2017) indicates that a decision to adopt a certain paradigm and research design is predicated upon its suitability to fulfilling purpose of study. The adoption of an ethnographic study approach was to explore the worldviews of the Zulu IK holders and Science educators on the phenomena under study. It was naturalistic in the sense that, the research was conducted in the participants' natural environment and niche because the objective was to observe and describe the research participants' worldviews on the focus of the research in their particular contexts. The design provided for the collection of rich, detailed qualitative data for description (Cohen et al., 2013; Olsen, 2011). The interpretivist paradigm encapsulates interpretation of multiple realities and was deemed appropriate in this study (Bertram & Christiansen, 2014; Quaye, 2007).

Research Context

The research was conducted among the Zulu cultural group in some local communities within the Zululand District Municipality: Nongoma, Ulundi, uPhongolo and Nkandla (King Cetshwayo district), in the Province of KwaZulu-Natal in 2018. The choice of the participants, the localities and guidance for getting access to participants was informed partly by literature, the DSI-NRF Centre in IKS offices in UKZN and recommendations from other participants in a snowball fashion. Zulu cultural practices are still relevant in these areas among others (Adeyemi, 2012; Creswell, 2017). The participants included Zulu IK-holders and science educators. The Zulu IK-holders whose transcripts and narratives were used for the research were 21 people of African origin: three chiefs (ndunas), three diviner-spiritualists (sangoma), three diviner-herbalists (inyanga), three elders (umdala); three youth (ubusha – the isiZulu word for youth); three science educators from rural areas. Three science educators from township and city areas were included. The participants were engaged in an in-depth conversational interview where there was dialogue. The number of participants was considered large enough to generate data for analysis and small enough to work with considering the pure qualitative interpretive nature of the data (Cohen et al., 2013; Creswell, 2017; Denzin et al., 2008; Miles & Huberman, 1994).

Data Gathering and Instrument

The key instrument for data generation were open-ended conversational interview questions, which permitted participants to express their views without restriction and to talk at length, in a relaxed manner (Burgess-Limerick & Burgess-Limerick, 1998; Denzin et al., 2008). Knowles and Cole (2008) contended that interpretivist researchers majorly employ interviews in their quest to explore and describe people's perceptions, worldviews and understandings about a peculiar phenomenon. Kaya and Seleti (2014, p. 33) view the interview as an important data generation instrument for exploring IK related phenomena and people's attitudes and IKS beliefs. The interview questions were:

> *"How do you think you (the participant) and your cultural group's understandings, perceptions and practices for the value and care for nature (lands, plants, animals, waterbodies) should be taught. Why do you have these views?"*

Data Analysis

The data was analysed inductively, using thematic content analysis based on themes, concepts and similar features. Bamberg (2012) stated that during transcription, analysis has already begun. The transcript of each participant was read to identify patterns, regularities and commonalities in the responses of all other participants and then organised in categories and colour-coded. The general categories were based on participants' responses that were connected to the social, cultural, economic, political, religious, technological, biophysical aspects of the phenomena under study (how to teach indigenous environmental sustainability). Themes were then identified by sorting and re-categorising the initial general categories into more in-depth and more specific categories. Moreover, untypical dissenting views were also identified in the process. Again, in the quest to enhance the theme identification, the texts that had not been colour-coded (not linked to identified themes) were re-scrutinised in search for new themes. All the themes identified in the entire analysis process were then discussed and supported with relevant literature (Attride-Stirling, 2001; Bertram & Christiansen, 2014; Miles & Huberman, 1994).

Rigour of the Research

Rigour of the research was ensured with trustworthiness by employing multiple data generation sources and triangulation (Rule & John, 2011). Triangulation was ensured through using the same conversational interview questions for different categories of participants – IK holders and science educators (Creswell, 2017).

Limitations of the Research

The purposively selected participants had in-depth knowledge about the Zulu culture using a snowball participant selection technique and did not prioritize gender nor specific age brackets in the selection process. Consequently, the findings of this research could not be discussed on that basis. The research was conducted in an African language, isiZulu language, which was translated to British English by a language translator and an IKS expert in higher education research, whose mother tongue is isiZulu. There were instances where responses were transliterated for want of exact word matches because the researcher did not speak the African language of isiZulu. Some scholars assert that most researchers who deal with multi-lingual research studies are confronted with interpretive dilemmas (Regmi et al., 2010; Vithal & Jansen, 2012).

Research Results

Themes were generated from the data and these include visiting IK-holders and Touring Cultural places within local communities. The research findings are presented and discussed based on the identified and established themes (see Table 1). Participant categories are coded (Chief – C1, C2, C3; Diviner-spiritualist -DS1, DS2, DS3; Deviner-herbalist – DH1, DH2, DH3; Elder – E1, E2, E3; Youth – Y1, Y2, Y3; Teacher in rural area – Tr1, Tr2, Tr3; Teacher in town/city – Tc1, Tc2, Tc3). Participant code highlighted in bold (example **C1** for chief 1) shows the chief's response believed to elaborate on the corresponding theme. In instances where participants in the same category made similar statements, one of the quotes was selected at random and presented to support the theme. In an attempt to reduce the volume of data presented to support findings and for reasons of data saturation, only a single quote is presented for each of the seven different participant categories.

Table 1

How to Teach Indigenous Epistemologies (e.g., Environmental Sustainability) in Science Education Curricular

Themes	Categories of Participants and Number	Percentage (%)
Visiting IK-holders and Touring Cultural Places within Local Communities	All participants	100
Inviting IK-holders to School Science Classrooms to Teach as Experts of Indigenous Epistemologies	All participant	100
Teaching the Indigenous Epistemologies (e.g., of IES) with Indigenous Language and Indigenous Teaching Strategies	All participants	100
Conscientising Learners to Remember and Cherish Heroes of their Cultural Heritage as a Decolonisation Measure	All participants except Y3	95
Demystifying Mysteries Surrounding Indigenous Epistemologies and teaching the Wisdom behind them	All the participants except DS1, DH2	90.5
Developing Computer Programmes for Indigenous Epistemologies	All participants	100
Students and Learners Wearing their Cultural Costumes, Patronising Indigenous Products	All participants except Y3	95
Mixing the Westernised knowledge on (e.g., Environmental Sustainability) with Indigenous Knowledge on (e.g., Environmental Sustainability)	All participants except E3	95

Visiting IK-holders and Touring Cultural Places within Local Communities

Participants indicated that the cultural places in the local communities be toured and IK-holders visited. These are captured in the following excerpts:

> The **chief (induna)** said, *"…the teachers and their learners can pay us a visit in the places (cultural villages, rural areas etc) where they can easily interact with the knowledge holders…this will let the learners appreciate their cultural values and easily embrace them…" (C1, **C2**, C3).*

> The **elder (umdala)** said, *"…I suggest the school visit the cultural villages and spend some time with some of the experienced IK-holders of the Zulu culture…because at a distance you may have misconceptions about the knowledge-holders and some practices…" (**E1**, E2, E3).*

> The **diviner-spiritualist (sangoma)** said, *"…people normally have wrong perception about our work…because they usually don't come to see how we do our things…so the schools could organize themselves and come to visit us here and we will gladly teach them what our ancestors say about the things we have in nature…"(DS1, DS2, **DS3**).*

> The **diviner-herbalist (inyanga)** said, *"…it is important that the learners get to know what we do…so they do not feel ashamed of us…I think the teachers and their learners could organize themselves on planned visit to meet us to teach them what we actually do…how we care for the lands, waterbodies, plants, animals…which they will not hear in school…"(**DH1**, DH2, DH3).*

> The **youth (intsha)** said, *"…I do think that having an excursion to local places and teaching learners there will be the best since this aspect has to do with the nature studies …they could even visit the cultural villages to appreciate the knowledge of cultural people …" (Y1, **Y2**, Y3).*

> **Teacher** (**uthisha**) said, *"…I do think that if the schools tour places where there are cultural practices like the ones related to the natural environment…I am of the view that it will go a long way to enhance the teaching process…" (Tr1, **Tr2**, Tr3).*

> **Teacher (uthisha)** said, *"…tourism and excursion are ways of getting cultural knowledge of a people's environment… therefore if there is some frequent excursions and tour to some of the places where such cultural things are still relevant, it will boost learners' interest…" (Tr1, Tr2, **Tr3**).*

Inviting IK-holders to School Science Classrooms to Teach as Experts of Indigenous Epistemologies

Participants asserted that their elders (IK-holders) to be invited to the academic institutions to help in the teaching of their IK on environmental sustainability.

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The **chief (induna)** *said, "…knowledge holders should be exposed to the learners by calling upon them to come to the schools regularly to teach them lots of these practices that helped us keep our environment…" (C1, **C2**, C3).*

The **elder (umdala)** *said, "…when we invite elders who have in-depth knowledge about our culture, especially those who have high formal education background, it would boost the interest of the learners…"(**E1**, E2, E3).*

The **diviner-spiritualist (sangoma)** *said, "…we have the knowledge of our ancestors and they keep talking to us to able to help our community…the schools can invite us to come and teach the learners some of the things and it will make them more interested in the cultural things…"(**DS1**, DS2, DS3).*

The **diviner-herbalist (inyanga)** *said, "…you have to use experts in everything you do so you can get the best results… the teachers can organize regular programs and call us who have more knowledge in the traditional and cultural things to teach the learners…"(DH1, DH2, **DH3**).*

The **youth (intsha)** *said that, "…I think that the schools can organize some forums where they could invite the either the chiefs, sangomas, inyangas, elders and other traditional leaders to help in teaching the learners the cultural ways of caring for nature…" (Y1, **Y2**, Y3).*

Teacher (uthisha) *said, "…one of the best pedagogical strategies is to get a resource person in any technical area that you are teaching, and this will enhance the teaching and enable free flow of ideas, so I suggest the IK-holders of the Zulu cultural be invited for such teaching…"(**Tr1**, Tr2, Tr3).*

Teacher (uthisha) *said, "… I will suggest that experts in the field, that is IK-holders of the amaZulu culture be invited to assist in teaching the learners…"(Tr1, **Tr2**, Tr3)*

Teaching Indigenous Epistemologies with Indigenous Language and Indigenous Teaching Strategies

Participants called for the use of their indigenous language and their indigenous teaching strategies or pedagogies to guide the teaching of the cultural (IK) on Environmental Sustainability. The following are some assertions made:

The **chief (induna)** said, *"…because of politics we cannot use only our local language, isiZulu in our schools but it should be used to teach our children…they should teach the learners the way we were taught by our elders and ancestors…" (C1, **C2**, C3).*

The **elder (umdala)** said that, *"…if the teachers could teach the learners the wisdom of our ancestors on how we protect the nature and, in the process, use the isizulu language, it will make the learners love the cultural things you teach them…" (E1, E2, **E3**).*

The **diviner-spiritualist (sangoma)** said, *"…we should not throw away our language and use other people's language in our schools…it will make it easy and interesting…our own way of teaching (such as proverbs, stories, dreams from ancestors) are what they (teachers) should use but they can add their own…it is our wisdom, knowledge they should teach…"(**DS1**, DS2, DS3).*

The **inyanga (diviner-spiritualist)** said, *"…how can you teach someone their cultural practice without using their spoken language...even some of the wild plants and wild animals we do not even know their English names, how can we tell you about them with English…you should teach the things in our culture,…use same way we teach our people…" (DH1, DH2, **DH3**).*

The **youth (intsha)** said, *"…I believe that using the isiZulu language to teach will even make the teaching nice and interesting…the elders they teach you everything whether spiritual things or physical things so that you will be cautious in your actions to the natural environment…"(Y1, **Y2**, Y3).*

Teacher (uthisha) said, *"…in teaching aspects like this, using the local language will enhance it… the IK-holders would be the best teachers…we as teachers should endeavor to learn the way the IK-holders teach using stories, proverbs, fairy tales, dreams, taboos etcetera…we could even find our own way of incorporating other strategies…" (Tr1, **Tr2**, Tr3).*

Teacher (uthisha) said, *"…the indigenous language of the people have all the deep things (the deep knowledges and wisdom)…it must be the mode of teaching although we can intersperse with English but at least 80 percent of it must be isiZulu…the teaching methods could be diversified…" (**Tr1**, Tr2, Tr3)*

Conscientising Learners to Remember and Cherish Heroes of their Cultural Heritage as a Decolonisation Measure

Almost all participants (except Y2) reiterated the need for the academia to recognise the impact of the ancestors and heroes of their cultural group (the Zulus) and show gratitude to them and remember them in their teaching. The teachers and the learners are to decolonise their minds in such efforts. The following extracts expound this:

The **chief (induna)** *said, "…teachers should make their learners love, cherish, appreciate what is their own…their culture is their culture…they cannot take other people's culture…and always remember what their elders and ancestors have done for them to still have their culture intact and protected their natural resources (the lands, forests, water-bodies etc) and made available for them…" (C1, C2, **C3**).*

The **elder (umdala)** said that, *"…when learners are made to know much about their cultural values, how the ancestors have fought to keep their cultural values and natural resources…it rids their minds of the thought of having subservient culture…because some of our learners sometimes feel the white child is better than them…" (E1, **E2**, E3).*

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The **diviner-spiritualist (sangoma)** said, *"…learners should know the value of their culture so that they will appreciate us and the ancestors for great work they have done for us…they fought long and strong battles to keep what we still have in nature now…we should give them due respect..."* (**DS1**, DS2, DS3).

The **diviner-herbalist (inyanga)** said, *"…teachers and learners should all become conscious of the fact that their culture is their culture and their traditional leaders are their leaders…they cannot throw away their culture and leaders now and those heroes…"* (DH1, **DH2**, DH3).

The **youth (intsha)** said, *"…everyone in our culture should understand that our ancestors have done a lot for us…those in school should be confident of their culture and not feel the lifestyle of the Europeans, Americans, Asians are the only acceptable ways of doing things …"*(Y1, **Y2**, Y3).

Teacher (uthisha) said, *"…appreciating one's culture should also be a key area to consider in the in the teaching process… because any disinterest will make learners not be attentive to what will be taught…teachers and their learners, should recognize the efforts of the ancestors in ensuring the resilience of their culture and preservation of natural resources…"*(Tr1, Tr2, **Tr3**).

Teacher (uthisha) said, *"…learners would need to fall in love with the cultural practices and accept that their culture is their culture…the ancestors and the elders who ensured that our culture and natural resources are still preserved should be commended…and remove from our minds any colonialist damaging thought about our culture…"* (Tc1, **Tc2**, Tc3).

Demystifying Mysteries Surrounding Indigenous Epistemologies and Teaching the Wisdom behind them

Participants (90.5%) except for DS1 and DH2 indicated the need for teaching the wisdom behind their general Indigenous practices and perception related to their cultural value and care for nature. The following are excerpts:

The **chief (induna)** said, *"…it is not everything that you the teacher can tell the learners because they are young and some of the things are spiritual…you will need the wisdom of the elders (IK-holders) to be able to explain such things…do not put fear in them about the spirits in many of the natural things…just teach the knowledge and wisdom of placing value and caring for the natural resources…"* (C1, **C2**, C3).

The **elder** (umdala) said, *"…our elders say a lot of things about nature that are spiritual… some scary though, but we took it to heart because they were here on earth before us and might know better…we respected them…we didn't enter forests they said we shouldn't enter…the spiritual part that the school teachers do not know about, they should invite the elders (IK-holders) to come to the schools to teach…"* (**E1**, E2, E3).

The **diviner-spiritualist (sangoma)** said, *"…there are lots of things that the teacher will not be able to explain very well in school about our cultural practices unless the ancestors give them the knowledge and wisdom because there are a lot of spiritual things that are connected with nature…teachers should not tell the learners anything that frightens them about our natural resources though some of the spirits manifest in waterbodies, plants and animals…"*(DS1, DS2, **DS3**).

The **diviner-herbalist (inyanga)** said, *"…for instance some of the plant used for normal physical things can also be used for other spiritual things…the teachers should therefore teach the physical aspect and benefits that they know and invite us when it comes to the spiritual aspects…"* (**DH1**, DH2, DH3).

The **youth (intsha)** said, *"…our elders rarely tell you the reason behind some of the things they tell us not to do…they sometimes tell you scary stuff about some plants, water-bodies, lands, forests, wildlife…I think this should be changed and when teaching in schools the reasons behind things should be told the learners…"* (Y1, **Y2**, Y3).

Teacher (uthisha) said, *"…many of the cultural ways for taking care of nature are based on spiritual connectedness… sometimes they are scary and can cause fear in the learners about some natural components…notwithstanding, the elders have been able to use that to take care of many natural resources…"*(**Tr1**, Tr2, Tr3).

Teacher (uthisha) said, *"…our cultural people's way of caring for nature are mostly linked to spiritual attachment and such can cause fear in learners…such aspects should be removed…we should find out what reasoning the elders had before saying those spiritual things connected to some natural resources…"* (Tr1, **Tr2**, Tr3)

Developing Computer Software Programmes for Indigenous Epistemologies

Participants called for the development of computer programmes or software or App for the Zulu indigenous practices and perceptions such as their cultural values and care for nature. The following are some assertions made by participants:

The **chief (induna)** said that, *"…our generation now use computers and mobile phones…I suggest that the schools find ways of developing special computer program that the learners can use to study the cultural peoples' values and care which they place on the lands, water-bodies, forest and other things in nature…"* (**C1**, C2, C3).

The **elder (umdala)** indicated, *"…learners are more interested in computer and phones than our traditions…and may be the reason why they are not respecting the wisdom of the elders…some computer programmes could be made that contains the wisdoms, practices, values and our cultural ways of caring for our natural environment…"* (E1, **E2**, E3).

The **diviner-spiritualist (sangoma)** said that, *"…now people believe more in computers, television and phones so they*

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*do not even bother themselves about our culture values and what our ancestors say about our water-bodies, plants and animals…so I think the school can create something for our cultural values with computer for our learners…" (DS1, DS2, **DS3**).*

The **diviner-herbalist (inyanga)** said that, *"…some people think that traditional healing is not good because we are not using computers to heal and check the body of people as other doctors do…since learners are school where computers are used, it will be better if government and the school leaders create some computer programme that has our cultural things for them to learn…"(DH1, **DH2**, DH3).*

The **youth (intsha)** said, *"…we love computers games and use many google apps today…I think that if some kind of a computer programme or a google play store app is developed that has all our the various cultural practices…it can make the teaching very effective and interesting…" (**Y1**, Y2, Y3).*

Teacher **(uthisha)** said, *"…ICT is becoming a must in every classroom teaching and I am of the view that if a kind of a computer software is developed for cultural value and care for nature it will be more attractive to the current generation of learners…" (Tr1, **Tr2**, Tr3).*

Teacher **(uthisha)** said, *"…some modernized interactive tool…could be a particular apps or computer software that has detailed aspects of the cultural values and care for nature with details of the wisdoms of the elders…this may pique the interest of the learners more…" (**Tr1**, Tr2, Tr3).*

Learners Wearing their Cultural Costumes and Patronising Indigenous Products

Participants suggested that teachers encourage their students and learners to wear their cultural costumes and regalia and eat indigenous foods to encourage the teaching of their indigenous practices and perceptions such as their IES. Some participants made the following statements:

The **chief (induna) said**, *"…our learners must be encouraged to wear our cultural clothing regularly and consume our local foods often…" (**C1**, C2, C3).*

The **elder (umdala)** indicated, *"…the interest of our learners will be piqued in the teaching if they enjoy wearing our traditional costumes and eat our local foods more…" (E1, **E2**, E3).*

The **diviner-spiritualist (sangoma)** said, *"…our culture is endowed with many rich values…our traditional clothes are wonderful and gorgeous…our foods are rich and nutritious and do not give people diseases like the fast foods…please let our learners wear our cultural clothes and eat our foods…" (DS1, DS2, **DS3**).*

The **diviner-herbalist (inyanga)** said, *"…we have to inculcate our cultural things into our children…For instance our children should be encouraged and allowed to wear our traditional clothes in school and eat local foods…" (DH1, **DH2**, DH3).*

The **youth (intsha)** said, *"…I think it will look trending, if we go to school with our traditional wear and enjoy our traditional games and foods as well…" (**Y1**, Y2, Y3).*

Teacher **(uthisha)** said, *"…Cultural clothing could be worn especially on day of teaching our indigenous environmental value and care for nature…learner should be encouraged to consume local foods…" (**Tr1**, Tr2, Tr3).*

Teacher **(uthisha)** said, *"…It would be lovely if we keep creating the conscious of using and patronizing our local produced items and wear our traditional clothes as formal dresses too…"(Tr1, **Tr2**, Tr3)"*

Miixing the Westernised Knowledge (on Environmental Sustainability) with that of Indigenous Knowledge

The research participants called for infusion of their IES ethics with the Westernised ES. Participants articulated that:

The **chief** (nduna) said, *"…the teachers should teach our cultural ways of caring for nature together with what is already been studied in schools…" (C1, **C2**, C3).*

The **elder** (umdala) said, *"…the teachers should not only teach our local ways of taking care of the earth but mix with the ones they teach in school…"(**E1**, E2, E3).*

The **diviner-spiritualist (sangoma)** said, *"…It will be good if our teachers add what we do in our culture to take care of nature to the ones from other cultures that the schools teach so that our learners will know more…" (DS1, DS2, **DS3**).*

The **diviner-herbalist (inyanga) indicated that**, *"…the knowledge and wisdoms of our elders that we use in taking care of the plants, animals, waterbodies, forests, lands should be taught together with the ones that the ones in the school and not be thrown away…it's good to have knowledge in many things…"(**DH1**, DH2, DH3).*

The **youth (intsha)** said, *"…these days even music when you blend with that of other foreign ones, they are unique and lovely…so I suggest that the teachers combine how our cultural people care for nature with that of the westernized ones in our schools…" (Y1, **Y2**, Y3).*

Teacher **(uthisha)** said, *"…an integrated approach to the teaching of the cultural environmental ethics with that of the westernized ones will be better I believe…"(Tr1, **Tr2**, Tr3).*

Teacher **(uthisha)** said, *"…in my view we should find an appropriate strategy to interface the nature studies with that of our local culture's care and value for natural resources…"(**Tr1**, Tr2, Tr3).*

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Discussion

The participants called on teachers to organise their learners and tour local communities with them to the cultural places; engage with the local community members and most especially interact with elders (IK-holders) to teach some of the Zulu people's knowledge and wisdom regarding their natural environment. Mosimege (2005) contended that cultural villages could provide educational purposes. Mawere (2015) asserted that integrating IKS in schools would promote the connection of learners with their culture. Khupe (2014) indicated that learners could go to places like museums where they could learn about indigenous knowledge. The wealth of (indigenous) knowledge of the IK-holders was appraised by the participants, and reiterated that the schools invite them over to the schools to teach some of the Zulu cultural values and care for the natural environment and the IK connected to their livelihood, in this research the environmental sustainability.

Michie (1999) indicated a development of curricula in Canada where elders were called upon for guidance and information. Simpson (2002) called for involvement of the elders in teaching the cultural curriculum, while Hewson et al. (2009) contended for collaborating with IK holders and hopefully inviting them to the classroom.

Participants were of the view that, for effective teaching of culturally related knowledge and indigenous practices (for instance, IES) the teaching should be done in a similar fashion to that of their IK-holders with a level of modification that fits with the formal schooling system. Most notable in participants' expression was the use of the indigenous (isiZulu) language as medium of instruction in all such teachings, for instance on their indigenous cultural values and care for nature. Kaya et al. (2016, p. 126) contended that "African indigenous languages such as isiZulu contributes to the promotion of African scholarship, African Renaissance and Africa-led globalization...and impart African cultural value systems in society, education and socio-economic development…provide students access to African indigenous knowledge and value systems". Nhalevilo-Afonso (2013) called for teaching content relevant to the cultural setting of the learners. The need for teachers and their learners making conscious effort to place great value on their heroes and on their cultural ways and caring for nature was reiterated by the participants. The cultural group are to show gratitude to the ancestors and heroes of the isiZulu culture for their bravery in fighting to keep their natural resources, their geographical land etc., and making the isiZulu culture resilient. Moreover, for the teaching of culturally relevant content to be effective, all and sundry within the academy ought to decolonise their mind by rejecting all subjugated thoughts about the isiZulu culture, which was precipitated by the colonialist.

The general view of the participants, especially the teachers and the youth were that their IK-holders usually make statements and tell stories about certain natural resources which are connected to spirits and metaphysical beings which are scary. The participants called on teachers to dispel unexplained and frightening statements attached to indigenous teaching on natural resources. Research by Opoku and James (2020) posited that teaching spiritual aspects of IK would pose a challenge to teachers as learners would demand proof and experiments to prove some claims connected to the natural environment. Shava (2013) contends that spiritual aspects are usually excluded from the curriculum because they do not conform to western ways of education on basis of being holistic. The development of a computer programme or software or google apps that has Zulus' cultural values and care for nature was suggested by the participants. The software could even be an interactive programme like google app game that could be put on phones to stir up the interest of the learners and to bring a certain consciousness that the cultural value and care for nature is a contemporary area of study. Moreover, the research participants reiterated that as a way of upholding their cultural values and cultural heritage, the learners, including their teachers should be encouraged to wear their traditional cultural costumes and regalia as well as patronize indigenous foods and locally produced products.

Doing this, is thought of to boost interest in teaching indigenous content in formal school setting. The participants emphasised the need for infusing the Westernised ES with their IES contending that much as their indigenous cultural values are to be upheld and highlighted, the already existing Westernised ES taught in the schools should not be removed but be integrated with the IES. Several scholarships have highlighted the need for integrating Western science with IKS (Bohensky et al., 2013; Mashoko, 2018; McPherson et al., 2016; Verma et al., 2016).

Based on the research findings, the analysis and discussions, (See Figure 1) a pedagogical model and guide for teachers, instructors and educators who have the quest to decolonizing, indigenising and transforming school science curricula at both basic and higher education institution is developed.

Figure 1

MJ Opoku' Culturally Pedagogical Model for Decolonising, Indigenising and Transforming Science Education Curricula
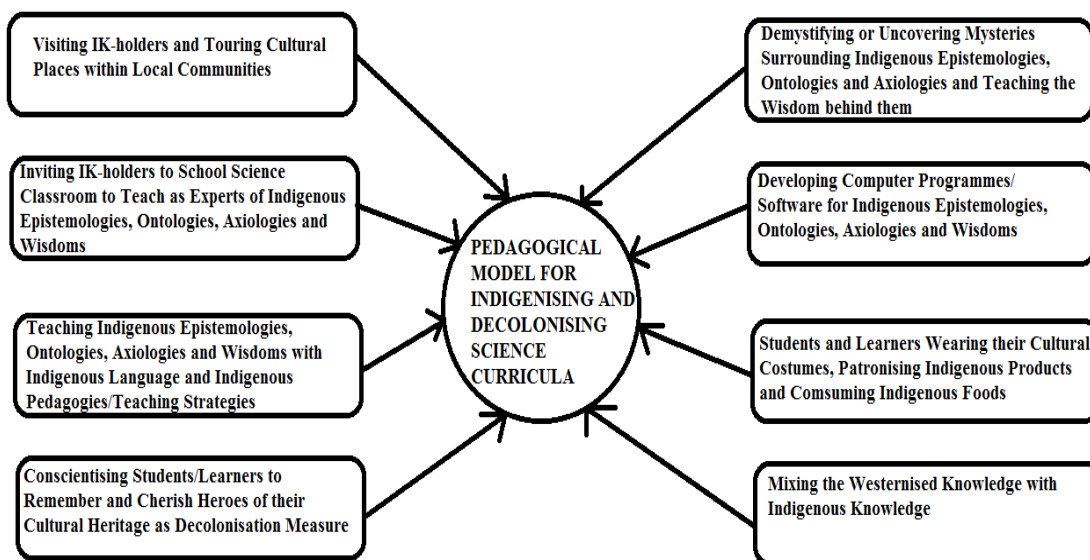
Conclusions and Implications

This research explored how indigenous environmental sustainability could be taught in the science education curricula, as viewed from the IK holders and science teachers in South Africa and why they have the particular views on how to teach indigenous environmental sustainability. The research is to contribute knowledge to the scholarship on recent call for africanisation, decolonisation, indigenisation and transformation of the science education curricula. The research results indicate the need to contextualise formal education processes for enhancing epistemological access for indigenous learners.

Based on the results of the research and the proposed pedagogical model, the cultural villages of the local communities are to be toured to promote interaction between educators, learners, students and community members especially the IK holders and to promote community engagement in general. When educators interact with their learners, they should inspire to cherish the heroes and legends of their cultural heritage who fought to keep their culture resilient. The IK holders need to be invited and brought into the formal science classrooms to teach the IK on e.g., indigenous value and care for nature.

In the teaching process, the IK holders are to be encouraged to teach using their unique culturally relevant pedagogical strategies, their local indigenous language and teach their indigenous epistemologies, ontologies and axiologies. The content taught should be demystified and the wisdom behind the spiritual connotations are to be taught. Learners should be encouraged to wear their cultural costume and regalia and motivated to patronise foods and their cultural products. Moreover, a computer-based programme or software or a google app containing all the local indigenous epistemologies, ontologies and axiologies should be developed as learning programmes, games etc.

The indigenous content taught, should not be done in isolation to the already westernised science taught in the schools but be infused and taught in an integrated manner but give more prominence and emphasis on the indigenous epistemologies.

The research recommends for further research into the development of resource materials for the diverse cultural groups and the use of these materials in the respective settings. Teachers and education officials require extensive interactions with the environmental ethics from an indigenous knowledge perspective through working with IKS holders who have the wisdom and willingness to share their knowledge.

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