

**Addressing Sustainable Development Goals by leveraging indigenous  
knowledge: Experiences of Science and Mathematics teachers**

By

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## ABSTRACT

The post-COVID era has illuminated the crucial role of education in reducing inequalities and promoting inclusive and sustainable growth. Literature is replete with rationales for higher education programmes to be aligned with the sustainable development goals through partnerships to ensure that programmes are globally and locally relevant. Based on these insights I adopted the *Ubuntu-currere* and decolonial theories as intellectual resources as I departed from traditional education norms which valorise only Euro-Western science and mathematics. I did this by exploring possibilities for leveraging indigenous knowledge to address the sustainable development goals in the curriculum. My study demonstrated the potential for transforming understandings of Education for Sustainable Development to include “low voices” in the production of valuable knowledge about sustainable living. I engaged 36 purposefully selected, practicing science and mathematics teachers who were enrolled in an Honours in Education module to generate qualitative data. I explored how science and mathematics teachers integrated indigenous knowledge to address sustainable development goals. Teachers participated in focus group interviews and engaged collaboratively with indigenous knowledge holders to develop portfolios of evidence, where they documented the stages of their work. They also taught lessons in micro-teaching sessions during which they demonstrated their ideas related to context, content, and pedagogy as they constructed and utilised IK to address the sustainable development goals.

Among the strategies that teachers used was to engage Chilisa’s (2012) processes of “Dreaming, Commitment, and Action” by re-imagining and practically enacting lessons for sustainable development using a decolonial lens. Specific ideologies from *Ubuntu-currere* such as social interactions through collaboration and challenging epistemic othering of IK informed teacher thinking and action. The findings from this study revealed that science and mathematics teachers address sustainable development using indigenous knowledge in sparse, indirect ways in the curriculum. Findings also showed that teachers were committed to exploring indigenous pedagogy and content as a strategy to address sustainable development goals in the curriculum.

Furthermore, my study revealed that science and mathematics teachers adopted specific strategies which resonated with work done during the teacher professional development programme in which they had engaged. This study also revealed factors that enabled or constrained teachers who sought to address the sustainable development goals by leveraging indigenous knowledge. The obstructive factors included issues of time management and an inherent lack of teacher capacity about content and pedagogy linked to indigenous ideologies and sustainable development.

Enabling factors were linked to the “democratic interactions” that teachers experienced through their engagements with indigenous knowledge holders, with their lecturers, and with one another. Teachers addressed obstructive factors by developing teacher agency and seeking assistance from more knowledgeable individuals who were supportive of their learning processes.

**Key words:** Ubuntu, sustainable development, professional development, democratic, indigenous knowledge

## DECLARATION

I, Sebastian Sanjigadu declare that:

- (i) The research reported in this dissertation, except where otherwise indicated is my original work;
- (ii) This dissertation has not been submitted for any degree or examination at any other university;
- (iii) This dissertation does not contain other persons' data, pictures, graphs, or other information unless specifically acknowledged as being sourced from other persons;
- (iv) This dissertation does not contain other persons' writing unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
  - a) Their words have been re-written but the general information attributed to them has been acknowledged;
  - b) Their writing has been referenced appropriately.
- (v) The work described in this dissertation was carried out in a Higher Education Institution in KwaZulu -Natal from 7<sup>th</sup> January 2020 to 5<sup>th</sup> December 2023 under the supervision of Prof. R. Mudaly (Supervisor); and
- (vi) The Ethical Clearance Protocol reference No. HSSREC/00002271/2021 was granted before undertaking the fieldwork.

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## DEDICATION

I dedicate this dissertation to my father, Mr. Sathiasivan Sanjigadu who is the greatest loss of my life. Sorrows may last for a season but your memory is everlasting. I will always remember to be kind through the example you set.

I would like to further dedicate this research to the indigenous knowledge holders who assisted the teachers in this study, and throughout Africa. Your voices are a light unto our path as we endeavour through the decolonial project together, "*Mayibuye iAfrika*".

*"Merely by describing yourself as black you have started on a road towards emancipation, you have committed yourself to fight against all forces that seek to use your blackness as a stamp that marks you out as a subservient being" (Biko, 1977).*

*I would finally like to dedicate this thesis to every young person who has battled issues of emotional and mental trauma. Rejection and abandonment are reserved for the gifted, never let it put out your light. "That is why, for Christ's sake, I delight in weaknesses, in insults, in hardships, in persecutions, in difficulties. For when I am weak, then I am strong (2 Corinthians 12: 10).*

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## **GLOSSARY OF ACRONYMS AND ABBREVIATIONS**

AIK - African Indigenous Knowledge

AU - African Union

CAPS - Curriculum and Assessment Policy Statement

DBE – Department of Basic Education

ESD – Education for Sustainable Development

FET- Further Education and Training

FGIs- Focus Group Interviews

HEIs- Higher Education Institutions

IK- Indigenous Knowledge

IKS- Indigenous Knowledge Systems

NDP - National Development Plan

NPC - National Planning Commission

OS – Observation Schedule

PD – Professional Development

SA – South Africa

SD – Sustainable Development

SDGs – Sustainable Development Goals

TPD – Teacher Professional Development

UN – United Nations

UNESCO - United Nations Educational, Scientific and Cultural Organization

WHO - World Health Organization

# **Chapter One**

## **Orientation of Study**

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## 1.1 Introduction and Background to the study

Tikly (2019, p. 223) argues that “if education is to play a transformative role towards sustainable development, education policy needs to be reoriented to address processes of economic, cultural and political transformation in the interests of social and environmental justice.” Within, the ‘postcolonial condition’, education, specifically Education for Sustainable Development (ESD) needs to be rethought on the African continent (Maringe & Ojo, 2017). Maringe and Ojo (2017) believe that African education needs to look towards Africa first and foremost, confront its inherent challenges of poverty and underdevelopment and reimagine a new identity. Ba (2017) notes that the postcolonial condition is one in which the globally disenfranchised (Black-African people) still navigate the social world according to Western standards.

The United Nations (UN) specialized agency for education called the ‘United Nations Educational, Scientific and Cultural Organization’ (UNESCO) is the leader in the Education Agenda 2030 (Lotz-Sisitka et al., 2017). Lotz-Sisitka et al. (2017) posit that education is UNESCO’s priority because it is a basic human right and the foundation on which peace and sustainable development (SD) is built. There needs to be a fundamental re-strategising of the education systems which involves focusing on SD and improving lives. Education Agenda 2030 forms part of a global movement to address SD through the achievement of the 17 Sustainable Development Goals (SDGs) by the year 2030 (Lotz-Sisitka et al., 2017). The focus of this study relates to all SDGs with a specific focus on SDGs 4, 10, and 17. Sustainable Development Goal 4 is focused on inclusive and equitable quality education, and the key focus of my study is on Target 4.7- Education for Sustainable Development and Global Citizenship By 2030, which according to the United Nations, seeks to:

ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture’s contribution to sustainable development (UN, 2015, p. 12).

Sustainable Development Goal 10 focuses on reduced inequality and SDG 17 is based on partnerships for the goals (Junior & Kokofele, 2019). All 17 goals interconnect, implying that success in one affect success for the others (Junior & Kokofele, 2019).

Padayachee et al. (2018) cited in Mudaly and Sanjigadu (2022, p. 2) posit that “both curriculum

decolonisation and ESD are necessary for institutional and broader societal reform and well-being, and both imperatives may potentially be achieved by focusing on principles of epistemically diverse curriculums". My study relates to the current educational debates in South Africa (SA) about decolonisation within the education sector. The #FeesMustFall campaign that swept across South African universities during 2015 and 2016 gave birth to other important considerations such as the calls for decolonisation of the curriculum and education as a whole (Heleta, 2016).

Power relations permeated debates about decolonisation of the curriculum and these debates continue to dominate the contemporary South African educational landscape. Calls for decolonisation in all facets of South African society have been at the forefront of discourses and debates. The overt call for decolonisation, according to Jansen (2017), took and continues to assume different forms. These calls gained momentum with the 'Fees must Fall', 'Science must Fall' and then the 'Rhodes must Fall' movements and extended to other issues which were central or peripheral to education. Decolonisation movements in whatever form, address the fundamental issue of ideologies and dominance. These have implications for the education sector, especially post-school education.

Padayachee et al. (2018) note the call for universities to adapt and revise their curriculums to respond to changing economic and societal needs, and to better prepare students for the rapidly changing world of work. Universities in SA and globally are also required to be an integral part of the societies they serve and have a pivotal role to play in addressing social injustices and shaping the future world (Padayachee et al., 2018). Institutions need to prepare students to contribute towards more sustainable societies and teacher education institutions are an integral part of this exercise. Padayachee et al. (2018, p. 4) identify the "need for university curriculums to be adapted to better prepare graduates for current and future uncertainties also echo the calls for universities to include more explicitly, the critical issue of sustainable development in all universities curriculums".

Lotz-Sisitka (2017) interprets decolonial theory and practice as a frame for ESD, to re-orient the purpose of higher education (HE) to the common good. Lotz-Sisitka (2017) notes that the issue of the common good is coming into focus in the global educational discourse on 're-thinking education'. The United Nations Educational, Scientific and Cultural Organization (2015, p. 3) affirms the need to see quality education as a common good, and suggests a new purpose for education:

Education must be about learning to live on a planet under pressure. It must be about cultural literacy, based on respect and equal dignity, helping to weave together the

social, economic, and environmental dimensions of sustainable development.

The concept of the common good is an aspiration that I seek to extend in my study. The decolonial theory was one of the theories that framed the way this study was approached. The understanding and conceptualisation of sustainable development need to be explored through decolonial lenses within higher education (Maringe & Ojo, 2017). Maringe and Ojo (2017) highlight the interconnection between decolonisation of higher education in Africa and sustainable development in their exploration of the meaning, rationale, and approaches for decolonised sustainable development in African higher education.

Some scholars argue that educational processes should have decolonial starting points (Rapple & Komatsu, 2016; Takayama, 2015; 2016) but these are not defined for the African context. I concur with Ndlovu-Gatsheni (2018) who believes that in Africa, decolonial starting points should be from an African viewpoint, a point where Africans become a part of the conversation. Mignolo (2011) believes that indigenous knowledge (IK) helps one to understand the decolonial project, which according to Matiwane (2017) encompasses more than addressing the remnants left behind by apartheid. Imperialism, poverty, loss of land, and inequalities are some of the challenges often attributed to the legacy left behind by apartheid (Mudaly & Sanjigadu, 2022). Mignolo (2011) states that decolonial thinking is more akin to the identity and thinking of indigenous people (and indigenous knowledges) than that of Euro-Westerners.

National policy documents like the CAPS and SA National Development Plans reflect growing interest in integrating IK systems/worldviews into the school and university science curriculum and education in general, with many reasons been cited such as political, axiological, and pedagogical considerations. For instance, political reasons are usually given to argue for anti-racial and multi-cultural education which emanate from the philosophy of humanism and principles of equality and the need to observe the worthiness of education that respect all cultures and traditions (Taylor, 1994; Webb, 2014 and Zinyeka, 2016). And in the case of this study decolonisation falls under political reasons. Reasons for the inclusion of IK in education have also been cited by scholars (Taylor, 1994; Webb, 2014). The desire to exploit IK in relation to development, and the need to utilize alternative ecological knowledge (Webb, 2014) seem to be the main utility reasons for the inclusion of IK in the science education and education in general. These arguments include barriers and difficulties faced when learning science by learners of non-Western background (Webb, 2014) or in other situations by science learners who hold pre-existing worldviews that are not in harmony with scientific worldviews (Hodson, 2009). For instance, barriers and difficulties that may be faced are misunderstanding (Hodson, 2009), epistemological 'border crossing' and clashes between the

culture of school science and local culture worldview (Webb, 2014).

Higgs (2016) coins the term '*trans-traditional vantage*' whereby educational practices acknowledge the validity of non-African knowledge systems and integrates this with African indigenous knowledge (AIK). Trans-traditional vantage, according to Pitcher and Jones (2018), means that decolonised educational curriculums and research should be cognizant of other knowledge systems (whether they be Euro-Western or African or other) and be integrated with local knowledge systems. *Trans-traditional vantage* is important for the decolonisation of education in Africa because decolonisation does not "only attempt to revive and reinstate indigenous knowledge systems (IKS) but also take into account modernity and industrialization" (Higgs, 2016, p. 46).

Le Grange (2014, p. 13) refers to 'Thinking Africanisation' of the university curriculum as an "immanent plane implies flattening hierarchies– the smoothing of space that will create unpredictable and creative flows from university to/from communities – flattening of hierarchies where one knowledge system is not viewed as superior (Western) and another as inferior (indigenous)". Trans-traditional vantage will be used in my study with the understanding that Euro-Western epistemologies present in the science and mathematics curriculums will be de-centered within a decolonised curriculum. The inclusion of relevant indigenous epistemologies and Euro-Western epistemologies in both science and mathematics curriculums will form the basis of a decolonised curriculum, and in this way, the plurality of knowledges will be embraced. There are however other debates and divisions within decoloniality with some scholars arguing for the total dismantling of Euro-Western epistemic traditions (See Madlingozi, 2017; Modiri, 2016), while others call for the re-centering of African knowledge (Ndlovu-Gatsheni, 2018, 2015; Maldonado-Torres, 2011). My work will recognise these debates but will include the contribution of Euro-Westerners and their knowledge to the science, mathematics, and research-focused disciplines while considering current decolonial discourses which are related to contestations about the curriculum. I draw on a plurality of knowledges by reviewing the work of both global North and global South scholars throughout my study.

According to UNESCO (2020), universities need to heed student calls toward the decolonisation of curriculums, as a part of broader society needing to align more closely with UNESCO's ESD agenda. This study seeks to adopt this notion within a teacher education institution (TEI) by focusing on a science and mathematics education professional development (PD) module at the Honours level. In this module, which formed an integral part of this study, teachers' engagement within the nexus area of SDGs and decolonising curriculums was explored. Leveraging IK within the

curriculum is one way of decolonising the curriculum in the SA context (Ndlovu-Gatsheni, 2018), and is the path towards decoloniality that I journey on in this study. 'Curriculum' is an integral aspect of my study, and I draw on curriculum policies to locate points of resonance with phenomena under exploration.

In the SA context, the principles of the Curriculum and Assessment Policy Statement (CAPS) curriculum include the move toward valuing IKS (Department of Basic Education [DBE], 2011). The details, however, on how to incorporate IK into actual classroom practice have neither been provided nor realised (Khupe & Keane, 2017). De Beer (2019) notes that although CAPS advocates for the inclusion of IK, it does not provide teachers with guidelines on how to do such epistemological border-crossing in the classroom. The CAPS document is also silent on the framework, sources, and approaches that teachers should use to incorporate IKS into their teaching. By using IK to address SD within the curriculum, a framework does emerge. The Life Sciences, Physical Sciences, and Natural Sciences as well as the Mathematics and Mathematical Literacy CAPS documents state that the examples of IK chosen to be used in these subjects should reflect South African ideology (DBE, 2011). Opoku and James (2021, p. 11) state that while IK content "is enshrined in the school curriculum, teachers experience challenges with implementing it, because the pedagogical strategies have not been clearly described." Maringe and Ojo (2017) believe that education for SD should draw on the natural knowledge capital found in African higher education and should refer to both inherited epistemological capital and the IK capital which is for the most part untapped. Decolonised education according to Maringe and Ojo (2017) should embed and develop IKS, and every curriculum subject should have a dimension of teaching and learning based on IKS, including science and mathematics.

## **1.2 Purpose and Focus of the study**

The purpose of conducting this study is to raise teacher awareness of colonisation and SDGs in the science and mathematics curriculum and to stimulate their commitment and action to work towards decolonising the curriculum, using perspectives from IK. The United Nations Educational, Scientific and Cultural Organization (2017) identified the professional development of teachers and the provision of teaching and learning materials as important to address SDGs through education on the African continent.

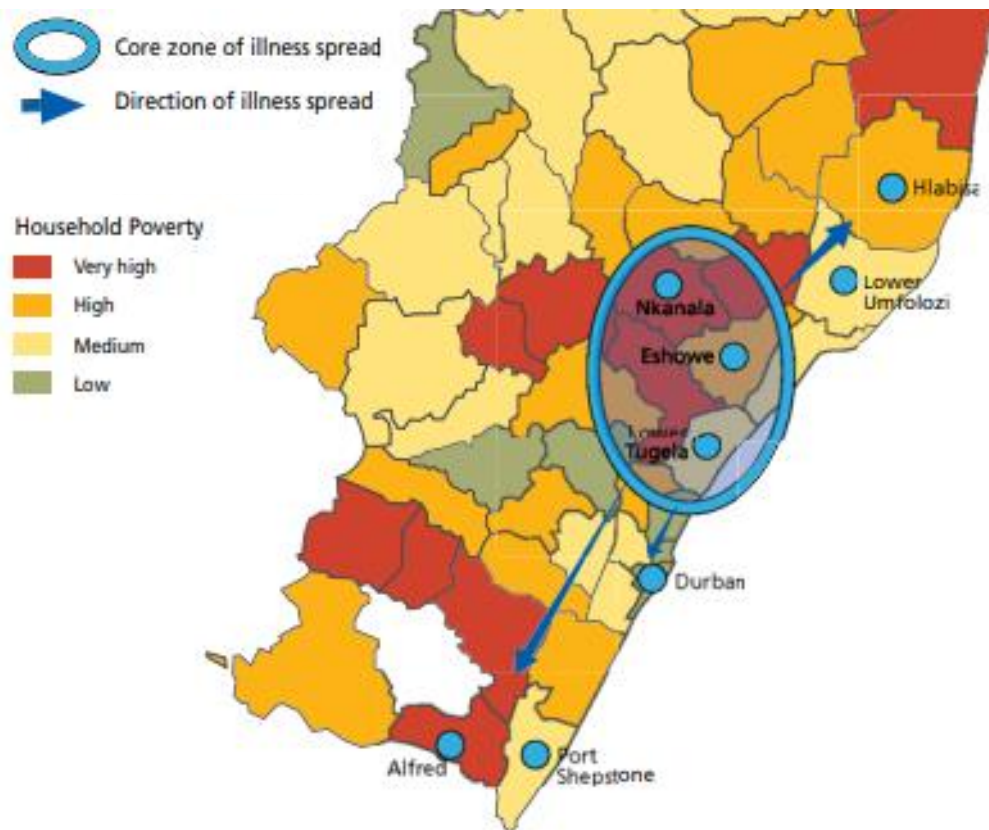
Lebeloane (2017) believes that introducing a decolonial understanding in the curriculum of Higher Educational Institutions (HEIs) as a part of IK pedagogy could facilitate decolonisation by promoting equity and social justice, which according to Mudaly and Sanjigadu (2022) are linked to sustainable

development. The focus on teacher professional development (TPD) in this study will be based on exploring how teachers decolonise the science and mathematics curriculums using IK to address the SDGs.

### **1.3 Location of study**

Hlatshwayo et al. (2022) argue persuasively that with South Africa's history of colonisation and apartheid, the country can serve as a context for exploring debates on decolonisation of education with a specific emphasis on curriculum development. This study took place in South Africa within the School of Education at a Higher Educational Institution in the province of KwaZulu -Natal.

KwaZulu -Natal was planned on apartheid principles which continues to inform the context in which we live (Govender, 2022). Developer-driven nodes (economic hubs) in the province are separated from the populous, which Govender (2022, p. 3) believes "creates divisions between cultural, socio-economic, and spatial hierarchies". KwaZulu- Natal records some of the highest levels of poverty, unemployment, and crime in South Africa. The high levels of poverty according to the UN (2015) directly speak to a lack of SD in the province. Poverty in the province can be attributed to the lack of knowledge about SD as well as a paucity of incorporating ESD into the curriculum (UN, 2015). Figure 1 Below maps out the geographical location of my study. The figure also aptly shows the household poverty levels which are inextricably linked to the spread of prevalent illnesses like Tuberculosis, HIV/AIDS, perinatal conditions, and respiratory infections in the province. These socio-economic and health challenges are the products of SD challenges prevalent in the region (David et al., 2018).



**Figure 1: Adapted map on the array of SD challenges in KwaZulu -Natal, South Africa (David et al., 2018).**

African cities differ significantly from cities in the West, and therefore require solutions from within, using African people to solve problems (including sustainability problems) from the bottom-up (Daniel et al., 2022). Bottom-up in the context of this study means developing local (bottom) ESD innovations to address global sustainability concerns identified by the UN (2015).

### **1.4 Rationale for the study**

The rationale for my study is underpinned by my professional experience as well as the recent discourse about decolonising education and the importance of sustainable development in South Africa. Lingán et al., (2012) believe that there is evidence that supports the view that education is a contributing factor towards improving livelihoods, economic growth, better health outcomes, reduction in gender inequities, higher levels of tolerance, enhanced political participation, and greater concern for the environment. There is a need for teachers and more especially science and mathematics teachers to engage with ESD (Padayachee et al., 2018). Lotz-Sisitka (2015, p. 34) argues that “South African teachers have a poor understanding of sustainable development and

therefore cannot integrate this into classrooms effectively”. Reddy (2017) identifies the cause for this by arguing that the DBE pays insufficient attention to sustainability education. Reddy (2017) states that SD education has historically been omitted in teacher education institutions. This study will be significant in creating awareness and understanding of SD among science and mathematics teachers at a SA University.

Wilmot and Dube (2015) identify several studies that have documented school curriculum shifts since 1994. This period coincided with the establishment of the democratic order in SA. These changes included centering viewpoints from black history, literature, and politics, and new school textbooks with revisionistic descriptions and interpretations of African and South African contexts (Balfour, 2015). Knight (2018, p. 271) notes that,

decolonisation and transformation in the academy are important topics under debate, they however also speak to other issues such as education access, funding, employment equity, diversity, and language policy, which are of relevance to national political debates.

Debates on these issues speak directly to the lack of sustainability. The lack of sustainability according to Lingán et al. (2012) means a loss of resources (both natural and human), a weakened economy, and a threat to human survival.

Bernier (2018) offers a solution to this by arguing for a systems-oriented curriculum that can adapt and include characteristics that are relevant to learners, these include IK. Gorman (2015) proposes we re-think how educational models are designed and focus on leveraging learners’ contexts and communities as valuable resources. Addressing ESD through decolonisation of the curriculum presents a new model approach to education (Clingan, 2015). In this study, I will propose a model which suits the global South context, especially that of SA. This model developed organically throughout the study culminating in a final proposed model in the theorisation (Figure 45, section 7.4, Chapter Seven). This position is informed by decolonial thinking that embraces ecologies of knowledge based on what de Sousa Santos (2018) calls the pluralisation of knowledge or post-abysal epistemologies. In my study decolonial thinking is based on African indigenous ideologies.

## **1.5 Positionality**

I have experienced life under the oppressive system of apartheid, and the change in the social and political milieu after the inception of the democratic political order. As a South African, one is never far away from the effects of colonization and apartheid, and I am no exception. The thirst for social justice became a part of my life. I studied the Honours module which is central to this study and which adopted a social justice approach, to inform my doctoral research. The imperative for this was to respond to the call for the decolonisation of HEIs (which include teacher education institutions) by scholars like Maldonado-Torres (2007, 2011), Ndlovu-Gatsheni (2015; 2018), Le Grange (2016, 2018), Heleta (2016) and Grosfoguel (2013). The Honours module included a topic that was dedicated to the decolonisation of the science and mathematics curriculums with aspects related to IK and SD. Personally, I think that climate change makes a contextually relevant ESD programme more necessary than in the past. Having been a secondary school teacher and a researcher, I saw this research opportunity as an educational innovation, because it sought to address the colonial onslaught on indigenous culture, and focus on SDGs.

## **1.6 Significance of the study**

The International Year of Basic Sciences for Sustainable Development (IYBSSD), celebrated in 2022, recognizes that basic sciences are vital to attaining SD and improving the quality of life for people all over the world (UNESCO, 2020). This study is timely in the context of the UN SD Agenda, and the IYBSSD, and will be significant to higher education teachers who work towards transforming and decolonising the curriculum. Cishe (2017) believes that there is a need to transform the teacher education curriculum so that it becomes relevant and contributes to SD. The study will be significant to science and mathematics school curriculum developers and science and mathematics teachers. Their understanding from this study could inform their work related to the curriculum, which is embedded in a social justice framework. Social justice in education can be achieved through epistemic justice (Anderson, 2012). Catala (2015) believes that epistemic justice is based on the democratic requirements of epistemic equality, legitimacy, and accountability. Epistemic justice could be leveraged by positioning IK holders as legitimate teachers in science and mathematics, and IK as valuable.

## **1.7 Research Objectives**

The objectives of this study are to explore:

1. How science and mathematics teachers address Sustainable Development Goals by leveraging indigenous knowledge.

2. The pedagogical experiences of science and mathematics teachers who have engaged in professional development activities in planning to address the Sustainable Development Goals by leveraging indigenous knowledge in the school curriculum.

The following two related sub-objectives were engaged with.

(a) The types of strategies science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address the Sustainable Development Goals.

(b) Why science and mathematics teachers who have engaged in professional development activities use the strategies they use.

3. The experiences which constrain or enable teachers who seek to address the Sustainable Development Goals by leveraging indigenous knowledge.

(a) The factors that obstruct or enable when leveraging indigenous knowledge to address the Sustainable Development Goals in the school curriculum.

(b) How science and mathematics teachers respond to these factors.

## **1.8 Research Questions**

The critical questions which are central to this research are:

1. How do science and mathematics teachers address Sustainable Development Goals by leveraging indigenous knowledge?

2. What are the pedagogical experiences of science and mathematics teachers who have engaged in pedagogical activities in planning to enact the school curriculum by leveraging indigenous knowledge to address the Sustainable Development Goals?

(a) What types of strategies do science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address Sustainable Development Goals?

(b) Why do science and mathematics teachers who have engaged in professional development activities use the strategies they use?

3. What are the experiences which constrain or enable teachers who seek to address Sustainable Development Goals by leveraging indigenous knowledge?

- (a) What factors are obstructive or enabling when leveraging indigenous knowledge to address Sustainable Development Goals in the school curriculum?
- (b) How do science and mathematics teachers respond to these factors?

## **1.9 Research Design and Findings**

This qualitative study located within the critical paradigm adopted a democratic participatory study approach. Participants were purposively selected using specific criteria. Data was generated through five qualitative methods, namely, by conducting focus group interviews (FGIs), observations of teachers' micro-teaching lessons, and document analysis of portfolios of evidence (PoEs) which were developed by teachers, as well as reflections. Field notes (FN) which I compiled were a part of the data set.

This study was designed based on the following research steps. Step A comprised a pilot study, Step B included the First Focus Group Interview (FGI1), and Step C involved teacher groups and IK holders who engaged in activities towards decolonising a science or mathematics unit of work by using IK to address the SDGs. Step D involved observations of teachers' micro-teaching presentations. In step E, document analysis of teachers' PoEs which contained lesson plans and other support materials used to develop their micro-teaching lessons, occurred. Step F was when the Second Focus Group Interview (FGI2) with teachers took place.

Findings revealed that teachers address SDGs using IK in sparse, indirect ways in the curriculum. It was also revealed that the types of strategies science and mathematics teachers who have engaged in PD activities use when planning to enact ESD in the school curriculum included a commitment to exploring indigenous pedagogical and content strategies. Teachers' commitment to re-imagining and enactment of a decolonised curriculum were related to Chilisa's (2012) dreaming and action stages of decolonisation. The findings also revealed that strategies obtained from the PD programme heightened teachers' knowledge about effective strategies to leverage IK and address the SDGs in the school curriculum.

This study also made visible factors that were obstructive to teachers addressing SDGs by leveraging IK, which were time management and teacher capacity. Factors that were enabling were democratic and social interactions to which teachers were exposed. Teachers responded to obstructive factors by seeking assistance from more knowledgeable others. Teachers also developed their agency through the self-learning process.

## 1.10 Overview of Chapters

In this chapter, I provided an orientation to the study which included background on decolonisation debates that emanated from HEIs and SD discussions. The purpose and focus of this study were then presented. I thereafter presented the geographical and ideological location which is linked to the rationale for pursuing this study. I explained the epistemological position of my study through a section I titled “positionality”. I also presented the significance of carrying out the study. Key research objectives and research questions that informed my study were then specified. I then described the research methodology used in this study. Insights into the findings of this study concluded this chapter.

Chapter Two focuses on the review of the literature with a specific focus on the SDGs with regard to the basic sciences, namely, science and mathematics, and specifically teachers achieving ESD within the curriculum. I also discuss the decolonial approach to ESD by drawing IK into the curriculum conversation. I also explore the nexus between IK, SD, and science and mathematics education to inform ESD praxis.

The theoretical underpinnings of this study are presented in Chapter Three. I offer a brief discussion on curriculum theories towards *Ubuntu-currere* as presented by SA curriculum scholar Lesley Le Grange (2021) and adopted by SA decolonial curriculum scholars Hlatshwayo, Shawa, and Nxumalo (2020). I also offer discussions on “coloniality and colonialism” as a preamble to discussing the decolonial theoretical lens that informs my scholarship.

The focus of Chapter Four is the research methodology, research design, research methods, and steps in the research. I begin by contextualizing this study and describing the qualitative approach and critical paradigm adopted. Purposive sampling and the democratic participatory design are also discussed. I conclude the chapter by discussing the ethical considerations, the trustworthiness of the study, and the limitations of this research.

A discussion of the data collected from the data collection methods is the discussion of Chapter Five. Responses to research questions that guided my study are also reported. This chapter also offers a presentation of data from the inductive (descriptive-level 1) analysis.

Chapter Six offers a more evaluative analysis of the data by drawing on literature and theories from global South, decolonial, and ESD scholars that inform related themes in the analysis of data. A discussion of the findings is also presented in this chapter.

In Chapter Seven, I present the organization of this research report, I also present a summary of research findings and a discussion of the “Decolonial Teacher Development SDGs model” that I propose within the theorisation section of this study. At the closure of this chapter and my study, I offer recommendations, implications for further studies, and conclusions that emerged from this study.

### **1.11 Summary**

This chapter presented the orientation in terms of background, the introduction of the study, and the focus and rationale of my study. I also presented my positionality and the significance of the study. I highlighted the research objectives and questions, design, and findings of this research. I ended this chapter with an overview of each chapter presented in this report. The next chapter, Chapter Two, contextualizes this study by reviewing literature that shaped my scholarly thinking and arguments.

## **Chapter Two**

### **Literature Review**

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## 2.1 Introduction

Two critical societal imperatives impacting the educational landscape in the contemporary South African context, namely decolonisation and achieving the SDGs are underscored. An overt call specifically for the decolonisation of education in South Africa emerged as a response to the exclusion of African people and their knowledges. I seized this curriculum moment to buttress contestations of the hegemony of the global North by exploring how tapping into IK from the global South, the African context, can mobilize teachers to work toward a curriculum model of ESD.

Apartheid, according to Shiva (2016), is the Afrikaans word for “separateness” and “apartness” and a political system that was founded on notions of racial superiority and inferiority based on skin colour. Apartheid is an ideology that goals like SDGs 4 and 17 seek to oppose. The concepts foregrounded in my study and discussed in the literature review are ESD, decolonisation of education, and teacher professional development. The decolonisation activities in my research will focus on indigenizing parts of the science and mathematics curriculums. The concept of IK with a specific focus on African Indigenous Knowledge (AIK) is critical to the strategy adopted towards the decolonisation process within my research. I do however discuss some IK from other global South contexts.

The concept of ESD on the African continent, and SA in particular, have not been clearly defined (Omer, 2020). The discussion of SD and the SDGs will offer insight into the purpose of ESD. There are no measurable criteria to understand ESD. There is however a global indicator database, the global indicator framework includes 231 unique indicators (United Nations Statistical Commission, 2018). Globally, the most prominent example of SDG measurement and monitoring is the SDG indicator database maintained by the United Nations Statistics Division (UNSD) (Joshi et al., 2021). Omer (2020) also mentions that the value of theory does not need to be measured using empirical impact indices such as the SDGs, but rather used as guidelines for more sustainable social, economic and environmental practices.

In my study, I underscore SDGs as these relate to science and mathematics teachers orientating their teaching by breathing life into the ESD concept within the SA curriculum context.

This literature review presents primary and auxiliary concepts that provide context to this study. I begin by defining and discussing sustainable development, focusing on the three pillars of SD, and moving on to discuss ESD in Africa and SA. I then discuss a decolonial approach to SD by relating

this to IK and the CAPS curriculum. Thereafter, I explore the link between IK, SD, and science and mathematics education. I will then discuss TPD and teacher learning focused on ESD.

## **2.2 Sustainable Development**

The most fundamental purpose of human beings is to live. However, human development over the past decades has led to “increasingly unfavorable climate changes, natural disasters, wars, and political and socio-economic instability” (Klarin, 2018, p. 17). Through these actions, humans have negatively impacted the environment, endangering the earth's survival and that of future generations (Klarin, 2018). Current environmental and economic challenges facing the world pose a threat to the existence of the future (Costanza et al., 2016). It is for these reasons that sustainability needs to be realized sooner rather than later.

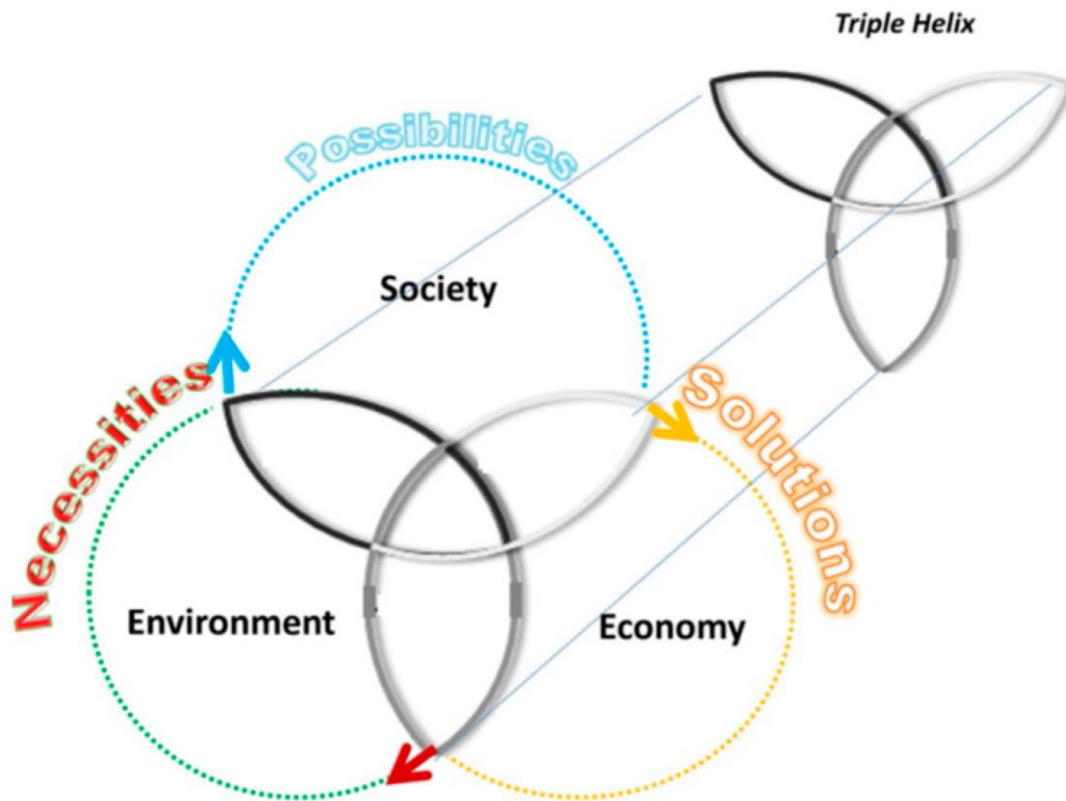
Sustainability can therefore be defined as “maintaining world processes of productivity indefinitely, both natural and human-made, by replacing resources without degrading or endangering biological systems” (Kahle & Gurel-Atay, 2013, p. 19). The SD section and associated discussions that follow here draw on many global North scholars; this is indicative of the origins and domination of SD discourses globally.

The idea of sustainability was originally proposed in July 2011 by the Governments of Columbia and Guatemala at an informal government meeting in Solo, Indonesia, and has since gained considerable political momentum internationally (Tikly, 2019; Lingán et al., 2012). Sustainable development considers the carrying capacity of natural systems as well as the social, political, and economic challenges humanity faces by focusing on the present generation's responsibility to regenerate, maintain and improve planetary resources for use by future generations (UNESCO, 2015). In 1987, the Bruntland Commission defined SD as “development that meets the needs of the present without compromising future generations' ability to meet their own needs” (UNESCO, 2015, p. 1), which is the definition that I adopt in my study.

## **2.3 Three Pillars of Sustainable Development**

The three pillars which influence sustainability and sustainable development are Environmental sustainability, Social Sustainability, and Economic sustainability (Klarin, 2018). When these three pillars intersect, holistic SD transfers into reality (Klarin, 2018). Klarin (2018) presents a commonly

accepted nested spheres model (commonly called the Venn diagram) to describe sustainability. I present the Venn diagram below in Figure 2.



**Figure 2: Adapted Venn diagram model of the triple helix of sustainability (Klarin, 2018)**

Klarin (2018, p. 68) states that:

The essence of sustainable development implies the balance between three pillars of sustainability – environmental sustainability-focused on maintaining the quality of the environment necessary to conduct economic activities and quality of life. Social sustainability strives to ensure human rights and equality, preservation of cultural identity, respect for cultural diversity, race, and religion, and economic sustainability necessary to maintain the natural, social and human capital required for income and living standards.

The diagram emphasizes key considerations above each pillar of sustainability, i.e., ‘Necessities’ above ‘Environment’, ‘Possibilities’ above ‘Society’, and ‘Solutions’ above ‘Economy’. My study lacuna exists in the realm of “Possibilities” within society by exploring what is possible within the

academy through ESD (the educational academy is an important part of society). Figure 2 offers a diagrammatic illustration of how the three pillars of sustainability are envisioned to interact and occur in a global community at large (Dong & Hauschild, 2017). Klarin (2018) states that if SD is to be realized there needs to be a specific focus on the different strata of society which are represented by the following three pillars:

### **2.3.1 Pillar 1: Environmental sustainability**

The first pillar, the environmental aspect, addresses the ecosystems and their life support functions for humanity (Dong & Hauschild, 2017). Arora (2018, p. 1) states that “human activities related to pollution have impacted every part of our world”. Shiva (2016, p. 64) coined the term “Eco-apartheid” as the “false and arrogant assumption that humans are separate from nature, that we are her conquerors, masters, owners, and the denial of the fact that we are part of nature, not separate from her”. Mudaly and Sanjigadu (2022) believe that the ever-increasing human population and increment in per capita consumption have put a great constraint on natural resources. In addition to this, modern agricultural practices have polluted water resources, air, and soil (UN, 2015). The UN (2015) notes that the earth is experiencing one of the most significant biodiversity loss phases, the impact of which is unforeseen and unpredictable. Environmental sustainability is thus one of the biggest challenges of the present time, garnering substantial attention from researchers, academics, governments, and non-government organizations involving individuals, communities, and countries (Arora, 2018).

Thangavel and Sridevi (2016) believe that at the environment level, sustainability prevents nature from being used as an inexhaustible source of resources and ensures its protection and rational use. Aspects such as environmental conservation, renewable energy investments, saving water, supporting sustainable mobility, and innovation in sustainable construction and architecture contribute to achieving this environmental sustainability (Dong & Hauschild, 2017). The UN has placed individual targets and indicators linked to SD to ensure and explore issues of environmental sustainability (Dong & Hauschild, 2017).

Stevens (2017) believes that environmental sustainability in practice ensures that in meeting basic human needs and other activities humans do for leisure, we do not damage the environment or deplete resources that cannot be renewed. South Africa is poised to address environmental sustainability through strategies to reduce carbon emissions through a growing investment in the alternative energy sector which has currently embarked on 92 projects valued at 3.2 billion dollars

(Cable News Network [CNN], 2022). These projects include decreasing national carbon emissions through the use of solar and wind energy plants (CNN, 2021). As the country moves towards environmental sustainability, the curriculum should be able to move towards offering teachers and learners the opportunity to learn about such environmental sustainability measures and the abovementioned innovations.

### **2.3.2 Pillar 2: Social sustainability**

Klarin (2018) explains that at a social level, sustainability fosters the development of people, communities, and cultures to achieve excellent and fairly-distributed quality of life, healthcare, and most importantly education. Social sustainability is an essential consideration since conditions of climate change and its ensuing uncertainties pose severe social and physical threats to contemporary human societies (Klarin, 2018).

Eizenberg and Jabareen (2017) note that popular definitions of social sustainability foreground social equity and justice by referring to diverse needs, inclusion criteria, opportunities, and privileges of the physical environment and of how community settings enable sustainable social outcomes. Social equity and inclusion are popular concepts present in policies governing South African society (Ndlovu-Gatsheni, 2015). Arora (2018) asserts that the individual and his/her actions within a society can either lead to societal sustainability or take away from it. Dempsey et al. (2012) enumerate physical factors associated with social sustainability, including urbanity, an attractive public realm, decent housing, local environmental quality and amenities, accessibility, and types of neighbourhoods. However, many communities in non-Western countries are decades away from achieving decent housing, amenities, and basic needs (Hickel & Kallis, 2020). Dempsey et al. (2012) highlight important non-physical factors that are necessary for social sustainability, including education and training (this study finds its niche here); inter- and intra-generational social justice, participation and local democracy, and health, quality of life, and well-being and social inclusion.

### **2.3.3 Pillar 3: Economic Sustainability**

Economic sustainability according to Hickel and Kallis (2020) focuses on equal economic growth, that generates wealth for all, without harming the environment (an example of the link between sustainability pillars). Investment and equal distribution of financial resources strengthen the social and environmental pillars of sustainability (Hickel & Kallis, 2020). Shiva (2016) laments that in the SA context indigenous people had to and still work as slaves, plantation workers, and mine workers

in the extractive economy of the coloniser. Economic disparities and racial discrimination flow from ecological apartheid (Shiva, 2016).

Wilson (2017) posits that economic sustainability became necessary because changes in the economic and natural environments coalesced to force organizations to alter their capital strategies. Jones et al. (2011, p. 258) emphasized “the need for organizations to become learning organizations to maintain economic sustainability”. Wilson (2017) believes that the learning that organizations seek should be based on the exploration of alternatives and long-term sustainability, not just driven by profits and wealth accumulation.

Ikerd (2012) believes that in a sustainable future the economy should emerge jointly with the essential decisions about environmental, social, and ethical dimensions of the world. The World Bank (2014) estimated that 75% of the world population lives on less than four dollars a day which emphasizes that economic sustainability can have significant effects on social sustainability. Reddy (2015) notes that constraints on resources such as oil, coal, natural gas, and uranium illustrate that growth fuelled by non-renewable resources is limited. The carrying capacity of the world has been breached and cannot be maintained by the resources found in it anymore (World Bank, 2014). Reddy (2015) argues that economic sustainability is affected by the investment choices institutional investors make and in return affects sustainability. An example is the recent ‘Shell Fracking debacle’ in which a planned seismic oil and gas exploration project by energy giant Shell off South Africa's Wild Coast region was set to begin in December 2021 (Le Roux, 2021). The exploration was expected to last between four and five months but environmental groups reported that many sea creatures will be affected, from whales, dolphins, seals, and penguins to tiny plankton, and this spells catastrophe for marine wildlife (Eastwood, 2021). The Shell company released a commissioned economic report from Econometrix, which claimed that up to 700,000 jobs would be created if the government allowed shale gas extraction to proceed, along with billions in revenue (Le Roux, 2021). Fracking involves the drilling technique which could damage the environment irrevocably. The water in the area could become contaminated and the chances of damaging aquifers are very high in a water-scarce country like South Africa (Eastwood, 2021). This will impact the sustainable development endeavors in the country.

## **2.4 The United Nation’s Agenda 2030 for Sustainable Development**

Agenda 2030, a plan of action for achieving SDGs proposed by the United Nations General Assembly, pays special attention to multiple issues, like gender equity, education, and culture which

cut across all the SDGs (UN, 2015). The 2030 Agenda proposes 17 SDGs with 169 targets supplemented with numerous indicators (Colglazier, 2015). Padayachee et al. (2018) note that Agenda 2030 places great emphasis on science, technology, and innovation (STI). Achieving the desired outcomes by the year 2030 will however require a deep understanding of how to maximize the contributions of STI (Colglazier, 2015). Agenda 2030 focuses on poverty and inequality which takes for granted that these will always be there (Scheyvens et al., 2016). It is too focused on a deficit model as opposed to an improvement model (Scheyvens et al., 2016). The agenda places the entrenchment of commercial relations and 'market-based' policy solutions at the heart of development, and initiatives crafted predominantly by actors who stand to benefit substantially from the continuity of neo-liberal rule (Weber, 2017). The SDGs are an intricate part of Agenda 2030.

## **2.5 The Sustainable Development Goals**

The SDGs replaced the Millennium Development Goals (MDGs) at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 (Costanza et al., 2016). The reasoning for this was to produce a set of goals that meet the urgent environmental, political, and economic challenges facing our world (UN, 2015). The MDGs seemed to focus on the European and Western notions of sustainability while marginalising needs in the global South (Costanza et al., 2016).

Some countries adopted the MDGs using a "piecemeal approach", choosing to engage with only some of the MDGs and not others (Junior & Kokofele, 2019). The MDGs were also seen as a sore point for many African countries that failed to achieve them (according to UN reports) (Junior & Kokofele, 2019). This failure has been attributed to the fact that the MDGs only applied to countries of the global North, and that global South countries had collectively played a minimal role in their design (Padayachee et al., 2018). Kincheloe (2008) identified ideological and epistemological inscriptions of mainstream knowledge frameworks, and the epistemic violence that occurs when people become lost because their knowledge systems are subjugated. The global South according to de Sousa Santos (2018, p. 30) is an "epistemological, nongeographical South, composed of many epistemological souths having in common the fact that they are all knowledges born in struggles against capitalism and colonialism".

The year 2015 marked a transition period from the MDGs to Agenda 2030 for SD (UN, 2015). The SDGs were a bold commitment to finish what had begun and tackle more pressing challenges that would face the world in the future (Costanza et al., 2016). The SDGs are a call to action, to end

poverty, protect the planet and ensure that all people enjoy peace and prosperity (Junior & Kokofele, 2019).

The SDGs and the MDGs although developed to help all nations are dominated by Euro-Western ideologies and implementations thus the need for a decolonial take on SD (Junior & Kokofele, 2019). Unlike the MDGs, which they replace, the SDGs seek to apply to all countries and represent goals and targets that articulate the need and opportunity for the global community to build a sustainable and desirable future in an increasingly interconnected world (Costanza et al., 2016).

The SDGs and targets according to Weber (2017) are integrated, indivisible, and globally applicable, taking into account different national realities, capacities, and levels of development and respecting national policies and priorities. The SDGs offer a coherent vision for sustainable development and are a useful tool for addressing broader development challenges in a comprehensive manner (Weber, 2017). Jomo (2016) highlights the significant systematic differences between the MDGs and the SDGs which are provided in Table 1 below.

**Table 1**

***Systematic differences between the MDGs and the SDGs (Jomo, 2016)***

<b>Millennium Development Goals</b>	<b>Sustainable Development Goals</b>
1. Conceptualised mainly for developed countries.	The SDGs endeavor to apply to multiple contexts (for all countries).
2. Offered 8 siloed goals for development.	Offered 17 goals, and 169 targets, integrating 3 dimensions (Pillars) of sustainable development.
3. Emanated from the United Nations Secretariat.	Negotiated by the United Nations member states with stronger country ownership.
4. The means of implementation, monitoring, and follow-up are not defined in advance.	Means of implementation are inter-governmentally negotiated, global architecture, and monitoring systems being shaped.

Jomo (2016) notes that the MDGs were not a negotiated initiative but merely a directive from the UN. The MDGs discourse focused on people thinking only about poverty and hunger whereas the SDGs touch on these aspects and more (Jomo, 2016). The SDGs much like the MDGs stemmed from the same need to address SD in a renewed way (UNESCO, 2015). The 17 SDGs are:

(1) No Poverty, (2) Zero Hunger, (3) Good Health and Well-being, (4) Quality Education, (5) Gender Equality, (6) Clean Water and Sanitation, (7) Affordable and Clean Energy, (8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure, (10) Reducing Inequality, (11) Sustainable Cities and Communities, (12) Responsible Consumption and Production, (13) Climate Action, (14) Life Below Water, (15) Life On Land, (16) Peace, Justice, and Strong Institutions, (17) Partnerships for the Goals (UN, 2015).

These development goals are multi-faceted and seek to address sustainability challenges across social strata (Mohamed, 2018). Weber (2017) explains that the adoption of the SDGs by all nations can also be called "Localizing the SDGs", where individual people, governments, institutions, and organizations work separately but on one or more goals at the same time. Within the current academic climate in SA, my study works towards "localizing the SDGs" through a decolonial lens by leveraging IK within the science and mathematics curriculum space.

## **2.6 Sustainable Development in Africa**

The idea of SD contributing both toward environmental conservation and socio-economic advancement emerged in scientific research and international discourse in the 1980s (Cobbinah et al., 2015a). Although there is an abundance of literature on SD in Africa, it remains to be demonstrated whether the ideology of sustainability has positive or negative effects on Africa (Cobbinah & Darkwah, 2017). There are, it is argued, little signs of progress toward SD in Africa (Cobbinah et al., 2015b).

Africa is a continent unique in its development challenges and opportunities compared to other developing regions of the world (D'Alessandro & Zulu, 2017). Africa is the most populous continent in the world, endowed with both human and natural resources (Oluwatayo & Ojo, 2018), but is home to some of the least sustainable countries (Azzarri & Signorelli, 2020). Economic growth and poverty reduction are central concerns in most global policy discourses at a time when the SDGs are fast gaining global relevance (Oluwatayo & Ojo, 2018). Africa has witnessed the highest but non-inclusive level of growth in the last decade because the continent still grapples with high unemployment rates (Azzarri & Signorelli, 2020). Economic growth recorded in the continent is a 'jobless' one advancing inequality and poverty where the wealthy get wealthier and those in poverty remain so (Oluwatayo & Ojo, 2018). Seventy-five percent of countries with low human development are in Africa with the continent's consistent economic growth imparting insignificantly on the

livelihoods of the people (Azzarri & Signorelli, 2020). There is no inclusion of the poor and vulnerable people in the continent's economic growth plans, and Oluwatayo and Ojo (2018) argue that inequality, poverty, and unemployment will continue to rise. One of the reasons for this could be that poor and vulnerable people lack the knowledge and skills to be able to integrate into a country's sustainability growth plans (Azzarri & Signorelli, 2020).

Moyo and Matondi (2008) argued that the inequalities of land distribution in countries like SA and Zimbabwe, where indigenous populations were dispossessed of their land by white settlers, produced land pressures that resulted in the degradation of the natural resource base. Given the heterogeneous effects of climatic events across Africa's macro-regions, local-specific adaptation and mitigation strategies are suggested to help bring households on a sustainable path (Azzarri & Signorelli, 2020). Tikly (2017) emphasizes the need for an urgent African approach to address SD on the continent. For the past three decades, the global community has recognized the need to shift the pursuit of development to SD (Ndonga et al., 2020). Omer (2020) motivates for a decolonised rationale steeped in IK and the Africanisation of the SDGs for implementation in Africa.

To achieve SD, African governments have launched several strategies (African Union [AU], 2015). The Ghana Poverty Reduction Strategy (GPRS I and II) and the National Environmental Policy (NEP) were designed (United Nations Economic Commission for Africa [UNECA], 2012). In Tanzania, the National Development Vision (NDV) 2025 was implemented (UNECA, 2012). In Egypt, there was the National Strategy for Solid Waste Management (NSSWM) (AU, 2015). Africa's endeavor toward attaining the SDGs through an Africanised framework is detailed within their very own Agenda, known as Agenda 2063 (Maringe & Ojo, 2017).

## **2.7 African Agenda 2063**

The African Union (2015) places Agenda 2063 as Africa's blueprint for transforming Africa into the global powerhouse of the future and is the continent's strategic framework that aims to deliver on its goal for inclusivity and SD. The African Union Commission (2015, p. 3) notes that Agenda 2063 is:

a concrete manifestation of the pan-African drive for unity, self-determination, freedom, progress, and collective prosperity pursued under Pan-Africanism and African Renaissance. The genesis of Agenda 2063 was the realization by African leaders that there was a need to refocus and reprioritize Africa's agenda from the

struggle against apartheid and the attainment of political independence for the continent which had been the focus of the Organisation of African Unity (OAU).

Despite attempts by African governments toward achieving SD, there is a growing perception that Africa could fail in achieving SD (Ndonga et al., 2020). This perception is fuelled partly by the evidence that while the world is undergoing rapid change, “which is driven prominently by recognition of, and remuneration for, its resources” (AU, 2015, p. 26), only 10% of Africa’s trade is within the continent, Africa exports only 18% of manufactured goods and imports 65% (Ndonga et al., 2020). These factors contribute greatly to the lack of sustainability on the continent (AU, 2015). Programmes that invest in AIK scholarship can be seen as one of the ways how Western control of our economies and knowledge could be neutralized (Boateng, 2013). In a South African context that would mean investment in “Nguni” indigenous knowledge scholarship. Lebeloane (2017) notes that the Nguni people made up of Zulus, Xhosas, Pedis, and other cultural groups make up 80% of the population in SA.

## **2.8 Sustainable Development in South Africa**

Joshua and Bekun (2020) declare that SD has been a challenge, especially in SA. The World Summit on SD held in Johannesburg, SA placed social justice at the heart of SD (AU, 2015). In the build-up to the World Summit, a series of organized demonstrations raised awareness of the plight of the landless poor in SA and their lack of representation in policy (Amanor & Moyo, 2013). South Africa is one of the most unequal societies in the world (World Bank, 2022). Black-African populations are forced to remain in overcrowded, communal areas, with poor infrastructure and support services (Amanor & Moyo, 2013).

Von Bormann and Gulati (2016) underscore the importance of food, energy, and water resources and their implications for development and planning in SA, where there is limited water, fertile land, and steady degradation of the environment. Many natural resources are becoming more challenging to access, thereby forcing exploration into less accessible resource zones associated with greater technical, social, and environmental challenges at increasing costs (Ololade, 2018). Add in the likely impacts of climate change, such as rainfall variability and extreme weather events, and the need for integrated planning informed by systems thinking arises (Ololade, 2018). Many South Africans are at risk of hunger, waterborne diseases, energy shortages, and greater poverty (Von Bormann & Gulati, 2016).

In September 2015, SA signed up for Agenda 2030 for SD, and the National Planning Commission formulated the National Development Plan (Mohamed, 2018). The vision statement of the National Development Plan emphasizes charting a new path for SA, which seeks to eliminate poverty and reduce inequality by the year 2030 (Mohamed, 2018). The plan is to change the life chances of millions of people, especially the youth, which remain stunted by the SA apartheid history (National Planning Commission, 2013). Indian scholar, environmental activist, scientist, and food activist Vandana Shiva (2016, p. 112) argued that “the real story of apartheid is colonialism and colonialists grabbing the lands of indigenous peoples, uprooting them from their homes and leaving them without resources, livelihoods and an economy that had sustained them over decades”.

Addressing an international call to achieve the SDGs that were made by the UN would also mean contributing to redressing the remnants of apartheid and working towards the development of SA because the SDGs are embedded in the National Development Plan 2030 (Tikly, 2017). The deep-seated sustainability challenges in SA were exacerbated by the recent Coronavirus disease (COVID-19) pandemic which magnified the SD challenges that had ravaged the SA society for years (Bob et al., 2020).

## **2.9 South Africa’s National Development Plan 2030**

Cumming et al. (2017) note that the SA National Development Plan is a local endeavor that links to the global call to address the SDGs. This is pertinent as the SA National Development Plan 2030 has a 74% convergence with the SDGs and prioritizes addressing SD challenges (Voluntary National Review, 2019).

Fourie (2018) claims that the challenge of aligning the National Development Plan with the SDGs is that the SDGs reflect the underlying assumption that developmental challenges transcend national and even continental boundaries. The SDGs are presented as all-encompassing global solutions to SD challenges (Fourie, 2018), but contexts vary in different countries. For example, SDGs focus on sustainable cities and communities (UN, 2015). This seems to be at odds with the National Development Plans explicit focus on rural development (Voluntary National Review, 2019), on establishing proper housing for people, and less on cities and communities (Mohamed, 2018). Tikly (2019) motivates an African approach to addressing the SDGs on the African continent and in SA. It is however important to note that the changes in global development thinking linked to Agenda 2030 will continue to impact how it is implemented in SA (Fourie, 2018).

A careful analysis of what the National Development Plan requires reveals that those who work in the education, training, and innovation sectors will play essential roles in the achievement of all the goals set out in the Plan (Education, training, and innovation in the National Development Plan 2030, 2013). At the heart of the National Development Plan is the notion of social justice in education.

## **2.10 Implications of Sustainable Development in South Africa**

The emergence of "sustainable development" as a key concept in the debate surrounding environmental issues has stimulated interdisciplinary dialogue (Görg et al., 2017). The issue of science, mathematics, indigenous knowledge, and SD fall within this dialogue which, in my view, is worthy of scholarly exploration. My view was further expanded by my attendance at the International Year of Basic Sciences for Sustainable Development Roundtable on 25/08/2022 to which teachers (my participants) were invited, some of whom attended (Appendix D).

Christie and McKinney (2017) note that the perpetuation of poverty for the Black-African person can be attributed to the colonisation of education and their curriculums. The majority of Black-African people in SA live in poverty, and SDGs (1) No Poverty and (2) Zero Hunger, explicitly offer guidelines to deal with these challenges. According to Görg et al. (2017), cultural variety is important when addressing issues of sustainability. There must be room for the social and cultural experience of different ways of life (Görg et al., 2017).

Oluwatayo and Ojo (2018) note the unchecked migration of young people from historically indigenous contexts to more industrial and technologically advanced spaces as a determining factor of poverty. Indigenous people thrive in indigenous contexts. Lamont (2018, p. 36) argued that "one may increase the level of self-determination and economic success among low-income or low-status minority groups by acknowledging or celebrating their distinctive cultural heritage".

Greater importance should be placed on local knowledge, including the understanding and practices of indigenous groups (Scott, 2017). Poverty in global South contexts results from a rise of low-skilled immigration from culturally diverse societies into economically advanced societies (where economic activities may take time to understand) (Lamont, 2018). Ndlovu-Gatsheni (2018) believes that African people should work within the decolonial project through IK if SD is to be achieved. Kaya (2013) asserts that indigenous knowledge was a tool used to cultivate care for the

natural environment, allowing indigenous people to exist more sustainably. Historically the type of senior citizens in society has an impact on the type of society in existence.

Senior citizens like parents and/or grandparents have knowledge, skills, and values that may define a specific societies ontological understanding (Christie & McKinney, 2017). Within my study, adult, IK holders who offered valuable knowledge about culture, traditions, and SD were recruited by teachers.

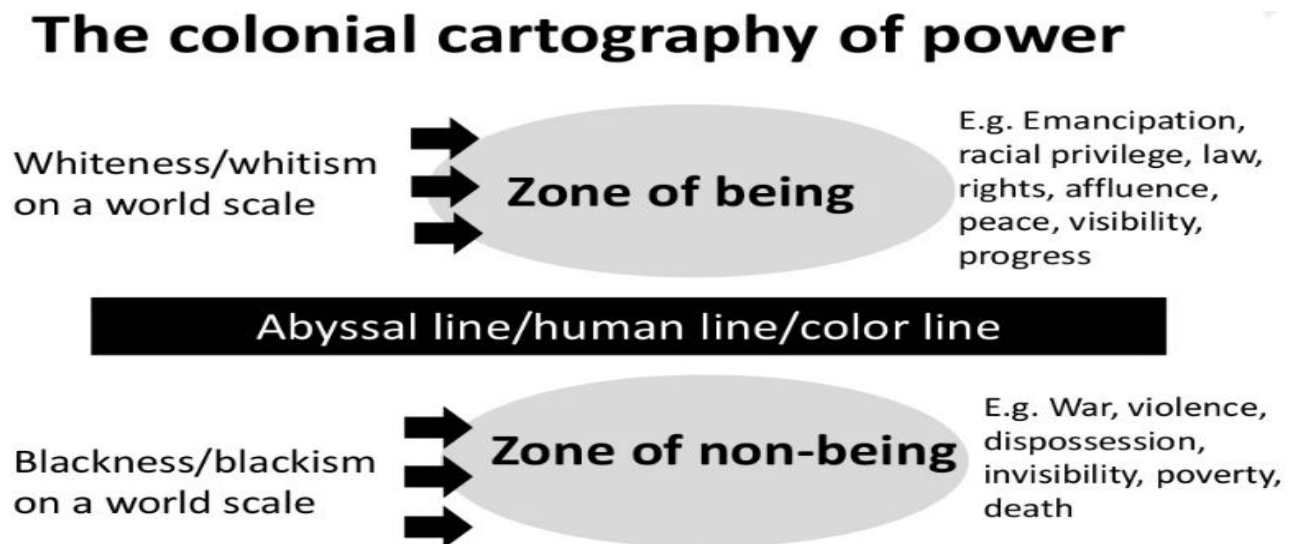
## **2.11 The Existential Being**

Gabriel (2018) argues that the nature of existence varies and is individualized are defined by our existence, and our existence is made up of our relationship to other people and things in the world. They believe each person must choose and commit to meaning and direction in life. Ekere (2022) argues that when Africa is compared to the global North in science, technology, and quality of life, Africa is underdeveloped. He argues that:

Africans have done less engagement than the West, not necessarily for lack of understanding of the laws of nature (science) or inability to translate understanding of such laws into the fabrication of tools (technology), but because of the disruption of the value system of the people, something that makes and indeed distinguishes people more authentically over and above colour and many other features (Ekere, 2022, pp. 326-327).

Ani (2013) argues for the re-evaluation of ways of being of marginalized groups that were, (and still are), subjected to colonial modes of production. Ahmed (2020) questions the validity of the SD initiatives to serve Black-African people when the view of the “black” according to Fanon (1967) is not a being or, the black is something else. Fanon’s views have ontological implications in that the African (black) view of self, his/her knowledge (indigenous) is not only devalued by those who are seen as superior, but by African people themselves. This particular instantiation is described in Fanon’s (1967) writing in the book “*Black skin, white masks*”. Africans cannot trust Euro-Western conceptions of sustainability because they were constructed to serve human beings in their contexts (Padayachee et al., 2018). Maldonado-Torres (2011) believes that colonial power relations impact the general understanding of a “Being”. Western philosophy particularly is “characterized by the forgetfulness of being and by a denial of the ontological difference” (Maldonado-Torres, 2011, p. 11).

The failure to understand the differences between other human beings negates their conceptions of sustainability (Ahmed, 2020). Maldonado-Torres (2011, p. 3) notes that “the philosophy and conception of the vocation of the human means a focus on the encounter between human beings and nature”. The people classified above the ‘Abyssal line’ dividing superior from inferior human beings are recognized socially as human beings and enjoy rights and social recognition of their identities, epistemologies, and spiritualities (Grosfoguel et al., 2015). Those classified below the Abyssal line are considered subhuman/non-human, their humanity is questioned and negated (Fanon, 1967), and these non-human classifications are generally placed on people of African descent (Grosfoguel et al., 2015). Below in Figure 3 is a diagram showing “the colonial cartography of power” presented by Ndlovu-Gatsheni and Mpofu (2019).



**Figure 3: Colonial cartography of power (Ndlovu-Gatsheni & Mpofu, 2019)**

Decolonisation is about identifying and overcoming the hierarchical dichotomy existing between North and South (de Sousa Santos, 2018). Understanding the cartography of power and the underlying principles that separate the “zone of being” from the “zone of non-being” in the context of my study became important. The “dispossession”, “invisibility” and “violence” (as identified by Ndlovu-Gatsheni & Mpofu [2019]) of IK and IK holders were addressed by teachers leveraging IK and working with IK holders to reconstruct units of work from the curriculum. Teachers addressing, amongst others, SDG 1 (No poverty) and 2 (Zero hunger) through their teaching create a discourse towards dealing with issues like “poverty” and “death”. I gravitate towards de Sousa Santos’s (2018, p. 63) “post-abyssal way of thinking”, which involves the search for ancestral knowledges and knowledges about how to live together sustainably. Removing the descriptors associated with being

identified as a “non-being” through post-abysal thinking is a step closer to neutralizing the dichotomy between what it means to “white” and “black” on a world scale.

Furthermore, de Sousa Santos (2018) believes that there is an abyssal, geographical line that Oxfam (2013) calls the “Brant line” which shows how the world was geographically split into relatively richer and poorer nations. According to this model: Richer countries are almost all located in the Northern Hemisphere, and poorer countries are mostly located in tropical regions and the Southern Hemisphere (Oxfam, 2013). Figure 4 below is a pictorial depiction of the Brant Line.



**Figure 4: The Brant Line presented by Oxfam (2013)**

My study seeks to contextualize the compounded existence of the non-being whereby people who occupy below the epistemological “Abyssal line” as well as below the geographical and material “Brant line” exist in a gross disempowered state which according to Maldonado-Torres (2011) create silenced voices and epistemological exclusions. Indigenous people in a SA context can be seen as those who were historically excluded from epistemological and possessional arenas. Through the contentions made by Ndlovu-Gatsheni and Mpofu (2019), Oxfam (2013), and Grosfoguel et al. (2015) it is my conceptual understanding that an individual can be geographically located in the global South but be epistemologically located in the global North as is the case in a historically colonised, post-1994 SA. Similarly, it is possible to be geographically located in the global North but be epistemologically located in the global South.

An African being located in a global South context should understand SD from an Afrocentric perspective (Ndlovu-Gatsheni, 2015). My study focuses on African beings (teachers and IK holders) taking ownership of the curriculum in their context through processes of self-learning and engaging in “autobiographical processes” like working from within as opposed to focusing on what is outside of the being (Pinar, 1978). The curriculum in the form of currere as an Autobiographical method will be further discussed in Chapter Three. Following Fanon (1967, p. 61) I envisage the ‘being’ and (teachers who are participants in this study in particular) as “fully conscious human beings free from coloniality and all its weakening effects.” For the coloniser, I adopt Madlingozi’s (2017) view of seeing them as a human beings removed from all biases of the abyssal imperial attitudes. My view of a human being encompasses everything an existential being living a sustainable life should be. The fundamental challenge of living a sustainable life for human beings is to understand sustainability (Clayton & Radcliffe, 2018). Sustainability understanding in-turn requires an educational-paradigm shift (Clayton & Radcliffe, 2018). The Education Agenda 2030 offers such a paradigm shift through the broader SD agenda.

### **2.13 Education Agenda 2030**

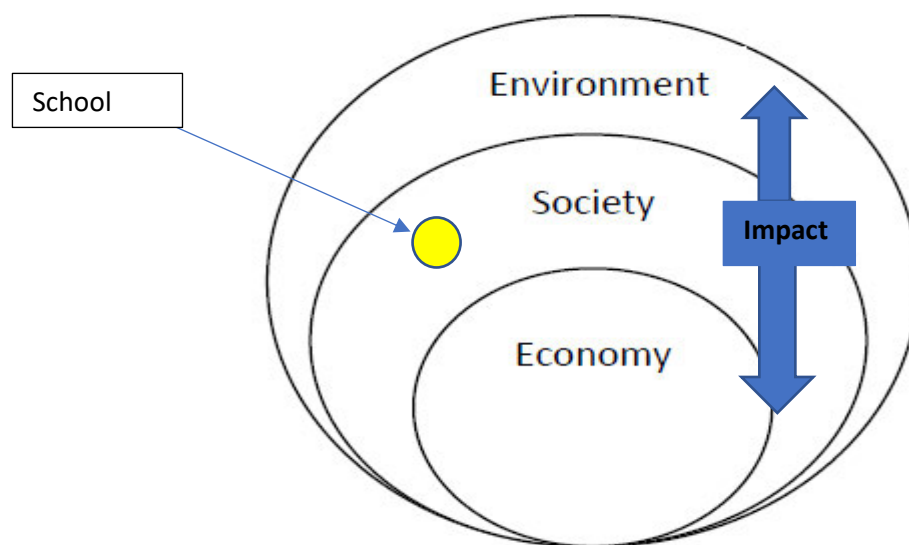
The Education Agenda 2030, adopted in 2015, provides a new international vision for education that is focused on the SDGs (Egron-Polak, 2016). Individuals need to be educated about the SDGs; the Education Agenda 2030 is a campaign toward this (Tikly, 2019). The main objective of the “Agenda” is to “ensure inclusive and equitable, quality education and promote life-long learning opportunities for all” (Tikly, 2019, p. 28). How countries can best plan for the implementation of this ambitious and comprehensive education vision needs to be explored (UNESCO, 2015). The United Nations Education, Scientific, and Cultural Organization (2015, p. 3) states that “education must be about learning to live on a planet under pressure, it must be about cultural literacy, based on respect and equal dignity, helping to weave together the social, economic and environmental dimensions of sustainable development”.

In May 2015, the UN together with its partners, subsidiaries, and global partners adopted the Incheon Declaration for Education 2030, which sets out a vision for the following fifteen years (Tang, 2015). The United Nations Educational, Scientific and Cultural Organization (2016) envisioned transformed lives through education, recognizing the important role of education as a main driver of development and in achieving the proposed SDGs. This vision is fully captured by the proposed

SDG 4 which ensures 'Inclusive and equitable quality education and promote lifelong learning opportunities for all' (UNESCO, 2016).

The United Nations International Children's Emergency Fund (UNICEF) (2015) underscores the unmatched power of education to improve lives, especially for girls and women (important individuals in society and focused on in SDG 5 [Gender Equality] and SDG 17 [Partnerships for change]). A fundamental part of Agenda 2030 is the recognition of the significant role that curriculums can play, particularly in providing the necessary platform and mechanisms for all humans to be active agents of change (Agbedahin, 2019). Teacher education is an important driving force behind the realization of the Education Agenda 2030 (Agbedahin, 2019). Teacher Education will be discussed later on in this chapter.

Barsan et al. (2011) attempt to describe the “Strong model of Sustainable Development” by highlighting the importance of education and the role of the curriculum to society which impacts the economy and environment.



**Figure 5: Strong Model of Sustainable Development with the location of the school within the 3 pillars (Barsan et al., 2011, p. 284)**

The adapted Venn diagram model of the triple helix of sustainability presented in Figure 2 shows the interrelation of the three pillars of sustainability based on 'Necessities, Possibilities and Solutions', whereas the 'Strong Model of Sustainable Development' (Figure 5) presents the three pillars within a sustainability nexus which considers the 'Environment' at the Macro-level system,

'Society' at the Meso-level system and the 'Economy' at the Micro-level system. Each of the three systems interact and influence the other. I present the school as an integral part of the societal-meso system, the impact of which reverberates and influences the economy and the environment. Both Figures 2 and 5 however present the three pillars of sustainability, their relativity to one another and can be viewed simultaneously for a holistic understanding about sustainability.

Bentham et al. (2014) consider the use of alternative knowledge as important to begin exploring sustainable development issues. The process of developing ESD takes place within the microcosm of the school, the school exists in the macrosystem of society which is a part of a larger network of systems (Barsan et al., 2011). Influencing the immediate society directly impacts the economic sector and the larger environment which makes up the mesosystem (Barsan et al., 2011).

## **2.14 Education for Sustainable Development**

Reddy (2017) notes that ESD discourse is necessary for teacher educators to understand the practice that is shaping the curriculum landscape. Singh (2011) argues that the organization and sustainable development values encompassed in an education system should be explicit within the curriculum. Education and the role of the curriculum impact the economy, society as well as the larger environment which are the aforementioned pillars of sustainable development (Singh, 2011). My study looks at bringing in IK holders to offer an oral record and discussion of sustainable development within the curriculum. Most knowledges present in indigenous ecologies of knowledges circulate orally and some have no written version (de Sousa Santos, 2018).

Barnhardt (2014) believes that including IK in education means developing school curriculums that appropriately incorporate local knowledge and ways of knowing into the curriculum. There is a need for ESD to be clearly understood by every individual (Tikly, 2019). Subjects at schools are key to enabling ESD to be relayed to families and into societies until a new sustainable culture is created in SA societies (Lebeloane, 2017).

The United Nations Decade of Education for Sustainable Development offered a list of ESD principles, with the acknowledgment that teachers in each context will interpret the principles slightly differently according to the values, needs, and priorities of their unique context. Education for sustainable development:

- is based on the principles and values that underlie sustainable development;

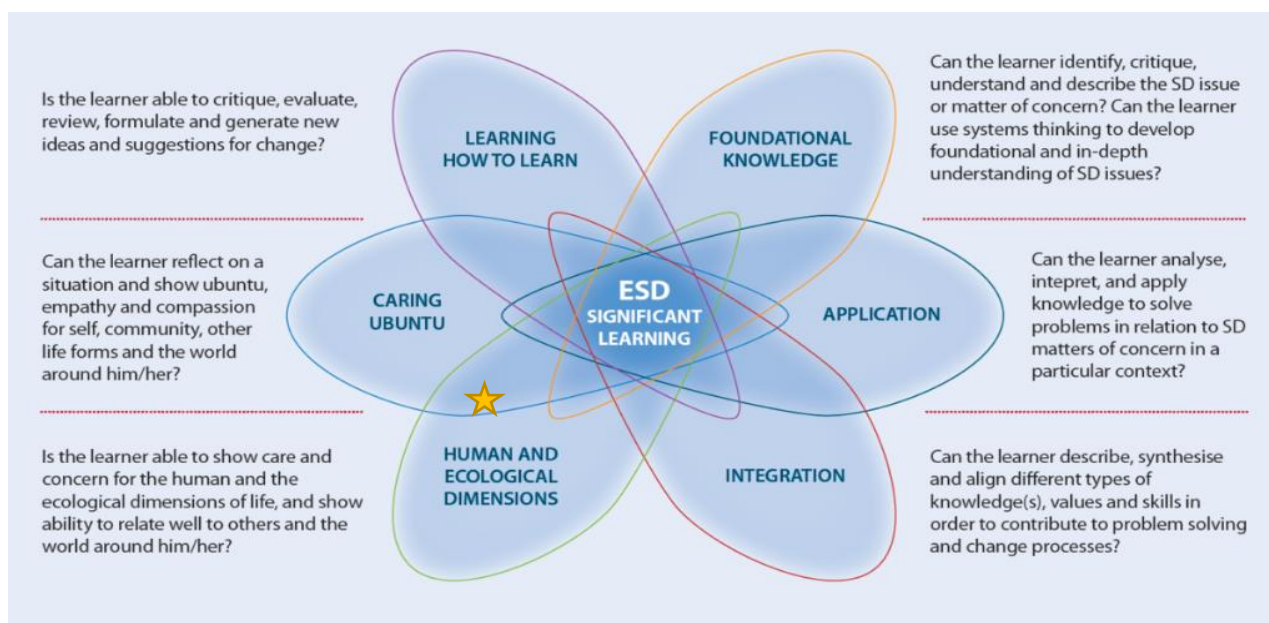
- deals with the wellbeing of all three realms of sustainability – environment, society, and economy;
- promotes life-long learning;
- is locally relevant and culturally appropriate;
- is based on local needs, perceptions, and conditions, but acknowledges that fulfilling local needs often has international effects and consequences; engages formal, non-formal, and informal education;
- accommodates the evolving nature of the concept of sustainability;
- addresses content, taking into account context, global issues, and local priorities;
- builds civil capacity for community-based decision-making, social tolerance, environmental stewardship, adaptable workforce, and quality of life;
- is interdisciplinary. No one discipline can claim ESD on its own, but all disciplines can contribute to ESD;
- uses a variety of pedagogical techniques that promote participatory learning and higher-order thinking skills [critical and creative thinking] (UNESCO, 2015).

Nasibulina (2015, p. 3) argues that in “global crisis education represents the most efficient way of forming a social and intellectual basis for the implementation of sustainable development principles and coevolution ideas.” Education for Sustainable Development is globally acknowledged as a powerful driver of change, which enables learners to make decisions needed to build a just and economically viable society respectful of both the environment and cultural diversity (Leicht et al., 2018).

The understanding of the term ESD in an African context should naturally be different and unique to African values and conceptions (Tikly, 2019). Within the pan-Africanist understanding of SD, ESD is understood as a vehicle for promoting African cultures, values, and knowledges (which are the uses of IK) (Tikly, 2019). An analysis of literature supporting ESD and a sample of its key products suggests that it failed to acknowledge or challenge neoliberalism as a hegemonic force blocking transitions towards genuine sustainability (Huckle & Wals, 2015). I seek to propose epistemological models which suits the global South context, especially that of SA which is based on a systems-oriented teacher professional development programme.

Education for Sustainable Development promotes significant learning. Shumba et al. (2020) offer an adapted model of Fink’s (2013) framework for significant learning which draws on systems

thinking with a focus on ESD. Figure 6 below shows a model of the adaptation of Fink’s (2013) framework of significant learning in ESD (by Shumba et al., 2020).



**Figure 6: Adaptation of Fink’s (2013) framework of significant learning in ESD (by Shumba et al., 2020)**

The framework for significant learning is what a teacher needs to think about when developing knowledge on any concept, and they can help to define the outcomes that the learners can achieve as they interact with the knowledge. Shumba et al. (2020) consider these questions in relation to learners engaging with SD issues to illuminate the dimensions of significant ESD learning. Significant learning is when a learner has the knowledge and can see connections and applications, and can see and care about the human dimension and the planet that is his or her home (Shumba et al., 2020). It aligns with the ‘learning as connection’ approach that Lotz-Sisitka (2013) describes as socio-culturally and situationally meaningful learning.

A key shift in educational thinking can be found in the emphasis on the multi-dimensional nature of learning, involving cognition, social-emotional engagement, normative commitments, and action and engagement orientations (UNESCO, 2020). My study is not focused on the assessment components of the model but rather on the systems-orientation and interconnectedness between the different types of significant learnings as will be described by Bernier (2018) in section 2.15 below. The six types of significant learning are synergistic, each interacting and relating to the other adding to significant learning (Shumba et al., 2020). Fink (2013, p. 57) explains that “achieving any

one kind of learning simultaneously enhances the possibility of achieving other kinds of learning as well.”

The specific loci I seek to enter into is addressing the SDGs through leveraging IK is found in the “caring-ubuntu” strand of learning. Ubuntu has been proposed as a useful alternative to current (Western) ethical frameworks (Cilliers, 2008). Authors such as Metz (2009), Komparic (2015) and Breems (2016) contend that Ubuntu is an African moral system that has been influential across a wide geographical area, and is principally a normative ethical system among the people of southern Africa. *Ubuntu* according to Molefe (2016) is an African term promoting togetherness and unity. The typical learning that occurs in SA classrooms is inherently and archaically based on Bloom's taxonomy (which fails to account for much of the significant learning that occurs in classrooms). I qualify *ubuntu* within my study through the theoretical lens of Le Grange's (2018) *Ubuntu-currere* (discussed in Chapter Three) whereby learning within a global South context needs to consider indigenous contexts and socio-cultural issues of the disenfranchised occupants of the global South (de Sousa Santos, 2018).

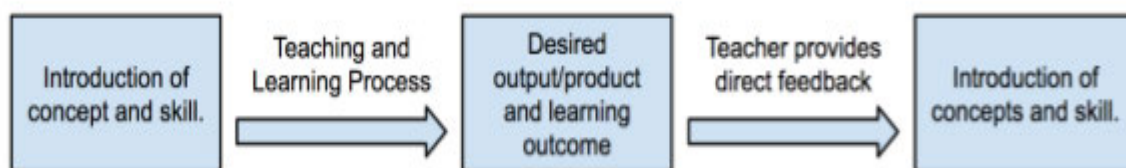
South Africa sought to encapsulate the 17 SDGs into its national policy documents and more importantly into its constitution and socializations (Voluntary National Review, 2019). In achieving the SDGs through the National Development Plan, the Voluntary National Review (2019) revealed that there is a need for deepening progress and making headway against our challenges which require enhanced stakeholder engagements and partnerships. The education sector made up of both higher and primary, public and private educational institutions is not excluded from the call for integration of the SDGs in their curriculum and governance policies (Voluntary National Review, 2019).

## **2.15 Systems-oriented curriculum**

Bernier (2018) asserts that standardization of education which involves imposing linear structures onto the curricular design inherently suppresses students' and communities' control of their educational experience. The exploration of ESD should not follow traditional linear formats that are inherently designed for curriculums not focused on SD (Tikly, 2019). Bernier (2018) believes a systems approach to curriculum design can alleviate oppressive curricular norms which are assumed by industrialized linear education.

As society has shifted to and from entire economic eras, education has been slow to shift with it, leading to numerous challenges in how and for what people are educated (Ellen MacArthur

Foundation, 2013). Education for Sustainable Development has taken heed of this and partially arisen from it to find a balance where a co-existence between humans and nature is sustained (Ellen MacArthur Foundation, 2013). This is linked to the systems-oriented curriculum understanding proposed by Bernier (2018). Bernier (2018) juxtaposes the linear-oriented curriculum with the systems-oriented curriculum. The linear model sees an introduction of concepts and skills which impact teaching and learning processes for specific outcomes (Bernier, 2017). Once outcomes are communicated the teacher provides direct feedback on these leading to the introduction of more concepts and skills which will drive the next phase of learning (Bernier, 2018). The first box and the last box are both labelled 'Introduction of concept and skill' which according to Bernier (2017) creates the expectation that all learners accomplish the same task and move on to the next (similar) task at the same time. Learners move from one task based on concepts and skills to the next without the detailed engagement of exposure to values and attitudes (Bernier, 2018). Figure 7 below shows the linear model of education design as presented by Bernier (2017).



**Figure 7: The linear model of industrial education design (Bernier, 2017, p. 2)**

The systems-oriented curriculum places focus on people and culture and bring to focus their needs and expectations (Bernier, 2018). It is this focus that makes the SDGs different from the MDGs, where the MDGs focused on products and goals whilst SDGs shifted the focus to processes and people (Jomo, 2016). This model is better suited to SDG 4 which is focused on inclusive and equitable quality education which encompasses the inclusion of different cultures, knowledges, and people.

Teachers ultimately drive the implementation of the curriculum in the classroom, the curriculum should follow a systems-oriented model as opposed to a linear one (Bernier, 2015). Bernier (2018) notes that when applying the concept of sustainable development to education, we must recognize that sustainability itself does not have an absolute end. Since the challenges that sustainability attempts to address are continuously evolving (much like a system), so must the learning process adapt accordingly (Bernier, 2018).

The linear curriculum model is too rigid and one-dimensional to address SD (Bernier, 2018). The systems-oriented model allows individuals to know how to learn, problem-solve, adapt, and critically think, which is the intrinsic end goal of effective sustainable development (Bernier, 2018). The systems-oriented model places responsibility on various stakeholders (like low-voices), not just teachers to implement the curriculum, whereas the linear model focuses on teachers and learners alone (Bernier, 2018). The systems-oriented curriculum is centred on ‘shared visions and goals’ which the curriculum, professional development of teachers, assessments, learning materials, and society contributes to (Bernier, 2018). Those ‘shared vision and goals’ in 21<sup>st</sup> century South Africa are SD as specified in the National Development Plan 2030 (National Planning Commission, 2013).

The linear model of ESD in the South African context for example is merely exploring causes of environmental degradation, managing environmental degradation, and defining solutions to environmental degradation (Bernier, 2018). There is no engagement with alternative solutions, stakeholder and community engagement, and reinvention or critical thinking (as is required in systems thinking) (Bernier, 2018). Linearity lacks the collaborative know-how necessary for SD (Bernier, 2018). My study engages these components within the model of ESD that I adopt.

Figure 8 below represents a form of Systems-oriented curriculum in a model proposed by Bernier (2018).



**Figure 8: Systems-oriented Model (Bernier, 2018)**

**Key:** All arrows show the interlink and bi-directional influence between the components in the system (↔).

All components in the systems-oriented models are interlinked and influence every other

component, the focus is that all peripheral components should influence an aspired vision or outcome (Bernier, 2018), in this case, that vision is ESD. When using the systems-oriented models, the focus is placed on examining inputs from learners, teachers, administrators of education, and resources (Bernier, 2018). In the African context, this differs because IK holders and communities come together for the education of a child (learner) (Lebeloane, 2017). This pedagogical ideology is steeped in *Ubuntuism* (linked to Fink's [2013] framework of significant learning in ESD [Figure 6]) and Africanisation (Le Grange, 2018). There has to be a focus on the operations and processes of the curriculum programme being implemented as well as the environment in which it is implemented (Le Grange, 2018). There is a strong focus on examining the outcomes of the curriculum, which are the views of both learners and teachers (Bernier, 2018). The exploration of ESD should not follow traditional linear formats that are inherently designed for curriculums not focused on SD (Tikly, 2019). Education for SD in Africa especially needs to follow a systems-oriented approach based on uniquely African conceptions (Tikly, 2019). This needs to begin with HEIs (Tikly, 2019).

## **2.16 The Curriculum and Education for Sustainable Development in Higher Education Institutions**

Seabi et al. (2014) believe that SA still grapples with attempts to eradicate the inequalities resulting from the apartheid system which created disparities between racial groups concerning housing, education, occupation, and health. Heleta (2016) notes that education is a seminal tool used to maintain and even perpetuate disparity and inequality.

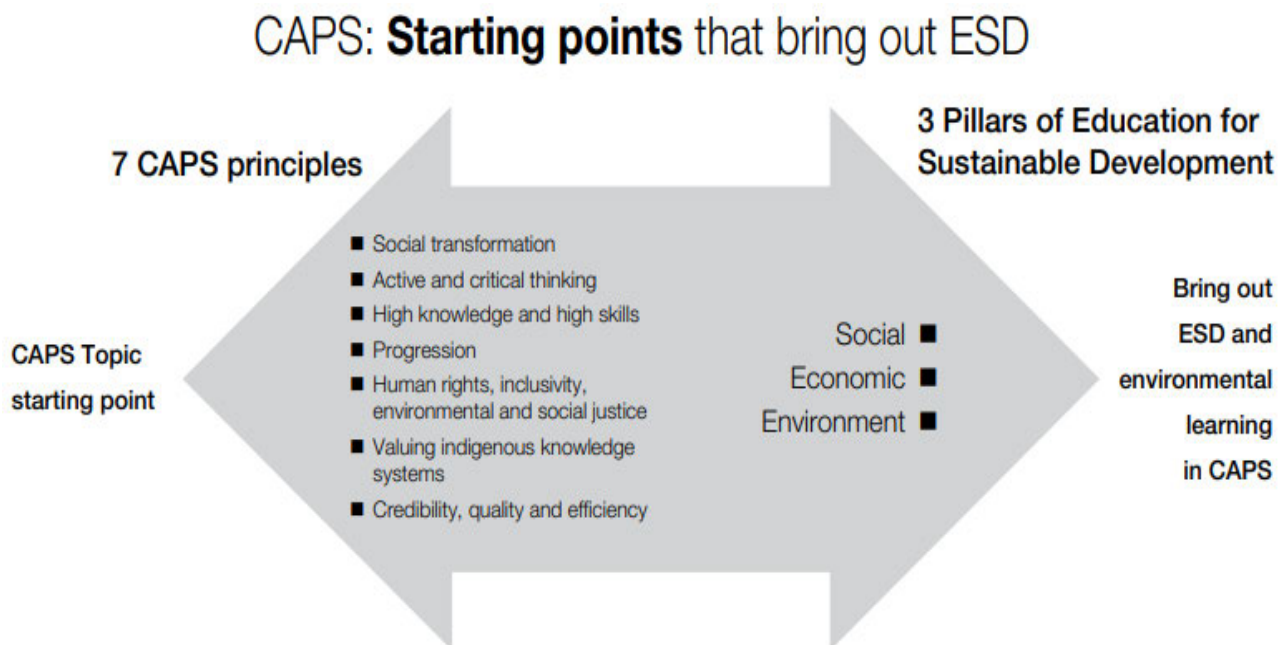
Given the legacy of apartheid in universities highlighted during the 2016/2017 'Fallist movements', the need to address SD, especially in the SA university context becomes an important consideration (Jansen, 2017). Knudsen and Andersen (2019) posit that the transformation agenda is premised on equality which is steeped in SD and underpinned by a decolonial agenda. Akala (2018) concurs by stating that teaching and learning at HEIs have shifted their focus toward achieving SD in principle yet much work is needed to achieve this practically.

Reddy (2017) observed a need to develop a deeper understanding of the CAPS, its assumptions, and the 'knowledge mix' expectations of teacher education policy. My study provided teachers studying a science and mathematics Honours module the opportunity to engage with curricular and content factors and engage with ESD. Knight (2018, p. 271) notes that "decolonisation and ESD within the academy are important topics under debate at South African universities, they also speak to wider issues on education access and funding, employment equity, diversity, and language

policy, which are of relevance to national political debates.” These wider issues speak directly to SD and the lack thereof.

## 2.17 Curriculum and Education for Sustainable Development at the Basic Education level

There is a need for teachers and more especially science and mathematics teachers to engage with and in ESD (Padayachee et al., 2018). The CAPS curriculum which SA teachers work with is based on a set of important principles which inform the design and development of all subjects (DBE, 2011). O’Donoghue (2013) believes that there are topics in the CAPS curriculum that lend themselves to ESD, and therefore is just a matter of taking these up and bringing out a sustainability focus in the curriculum. These principles are; Social transformation, Active and critical learning, High knowledge and high skills, Progression, Human rights, inclusivity, environmental and social justice, Valuing IKS and Credibility, quality and efficiency (DBE, 2011). These principles not only resonate with the 17 SDGs and ESD values but also positions IK as a guiding principle, one to aspire towards through the curriculum. Figure 9 below highlights the possibility of bringing out ESD learning in CAPS.



**Figure 9: Diagram of CAPS principles as starting points to bring out ESD (Fundisa for Change Programme, 2013)**

The principles found in CAPS serve as relevant starting points in which ESD values could be realized. Internationally ESD is influencing curriculum development at all levels and phases of the education system, and in South Africa, we can see the influence of new thinking about the environment, society, and economy in the CAPS curriculum (Fundisa for Change Programme, 2013). The United Nations Educational, Scientific and Cultural Organization (2019) believes that the basic sciences (defined as the scientific disciplines of mathematics, physics, chemistry, and biology) can be the vehicles for sowing the seeds of sustainable societies for tomorrow.

Education for sustainable development is important for recovering and mobilizing heritage-based knowledge and experience for the decolonisation process in SA and the global South (Jickling et al., 2021). Dussel (2019) in Jickling et al. (2021, p. 56) explains three major intersecting limits of colonial modernity:

- Ecological destruction of the planet is based on a conceptualisation of nature as an exploitable object.
- Poverty and Inequality are based on ongoing exploitation and accumulation of wealth.
- Narrow rationalities epitomized by colonial and imperialist thinking.

Dussel (2019) proposes a new, transmodern civilization based on absolute respect for life. Mudaly and Sanjigadu (2022, p. 11) note that “colonising nations held the belief that “the superior” should educate and bring civilization to “the inferior” African people, but this was exploited by the colonisers”. To achieve social control, colonisers misused education and removed the colonised people from their indigenous learning (Bulhan, 2015).

## **2.18 Decolonisation and Decoloniality**

Decolonisation and decoloniality offered a chance at change for African people born out of various calls from the global South. Decolonisation as a concept and as a process has been widely interrogated in but not restricted to South African universities, and has been highly contested, complex, and subjected to the socio-cultural phenomenon (which is linked to the social pillar of SD) (Padayachee et al., 2018). Decolonisation theorists such as Fanon (1967), Spivak (1988), and Wa Thiong’o (1986) clearly illustrate that the decolonisation process is complex and multi-dimensional, replete with conflicts, contradictions, and paradoxes. Decoloniality according to Mignolo (2011, p. 274) is a process of delinking and entirely “changing the terms of the decolonisation conversation

and moving toward a more decolonial dispensation.” The focus of my literature on concepts like decolonisation and decoloniality has informed the selection of the decolonial theoretical lens which I present in Chapter Three.

The approach to changing the terms of the conversation in this study is not to eradicate colonial forms or sources of knowledge, but to explore ways in which ESD can incorporate a SA perspective and more especially an IK element to benefit the education system and address SD. Decoloniality is important due to the 21<sup>st</sup>-century manifestation of Frantz Fanon’s (1967) idea that in a colonial world, subjugated groups do not have access to ontological resistance. The very notion of valuing one life over another is entrenched in the ignorance of equality (Fanon, 1967). Non-existent knowledges are perceived as such because they are produced by subjects deemed incapable of producing valid knowledge due to their perceived sub-human condition or nature (de Sousa Santos, 2018). Maldonado-Torres (2011) views decolonisation as an invitation to engage in dialogue in political spaces, through protests and movements, or in lecture halls and classrooms, the issues around decolonisation are a call for discussion.

Contemporary manifestations of coloniality were present even during the COVID-19 pandemic and subsequent access to vaccines. Ahmed (2020) reports that the colonial perspective was articulated in the alliance between France, the Netherlands, Germany, and Italy to negotiate priority access to the COVID-19 vaccine for themselves and the rest of Europe and highlighted that the alliance also worked to make a portion of the vaccines available to low-income countries in Africa. On one hand, African citizens were seen as ideal to test a COVID-19 vaccine but not good enough to be a part of the mainstream alliance which also had priority access to vaccines, Africans were only deserving of ‘a portion’ (Ahmed, 2020).

South African President Ramaphosa (cited by du Plessis, [2021]) said:

[The world] says, ‘No, we know what is good for you, we just want you to do fill-and-finish [of vaccine doses], that’s it... “We say, ‘We no longer want that. You did that long ago when you colonised us, and when you raped and pillaged our countries. We say ‘no’ now, we have the capability [to manufacture vaccines] and we want to make full use of it.”

This is an example of “global health colonialism” where vaccine politics result in “exploitation, marginalization, pathologization and saviourism” (Parker & Ferraz, 2021, p. 1133). This is

consistent with Comaroff and Comaroff's (2012) view that unequal power relations exist between the global North and the global South, where people in the global South are anthropologically used by those in the global North. The concept symbolizes how even the COVID-19 vaccine can be used as an instrument of power deployed to exercise control over who will live and who must die (Ahmed, 2020). For Fanon (1967) decolonisation, which sets out to change the order of the world, is, obviously, a programme of complete disorder. Acknowledging that even the COVID-19 vaccine has been weaponized as an instrument of power by wealthy nations, decolonisation requires a Fanonian programme of radical re-ordering (Ahmed, 2020).

For decolonisation within the African landscape to occur Oelofsen (2015) emphasizes that decolonisation needed to take place within the African mind first. Ahmed (2020) believes that Africans have a particular role to play in leading this decolonisation process as subjects of colonialism and as objects of domination through coloniality. African people need to take ownership of their curriculums (Ndlovu-Gatsheni, 2015). Hlatshwayo et al. (2022, p. 2) believe that "without addressing the curriculum question, decolonisation will remain located at the symbolic level and struggle to impact the institutional curriculum of universities."

### **2.18.1 Decolonisation of the curriculum**

Epistemologies of the South represent forms of knowledge that are generally "discredited, erased, and ignored by dominant cultures of the global North and that global justice can only come about through an epistemological shift that guarantees cognitive justice" (de Sousa Santos, 2018, p. 34). Shay (2015) defines decolonisation as the incorporation of African, SA, and global 'perspectives, and epistemologies' as the central tenets of the curriculum, teaching, learning, and research in the country. Fataar (2018, p. 7) proposes that decolonisation be "an incorporation of urgent conversation in policy circles, among curriculum workers, learning materials and textbook designers, and, crucially, among university lecturers and teachers". Fataar's (2018) propositions were taken into consideration when developing the research design of this study. Decoloniality begins with the recognition of "existential realities of suffering, oppression, repression, domination and exclusion" (Ndlovu-Gatsheni, 2015, p. 15). Mbembe (2015) focused on decolonisation in higher education, in particular, drawing attention to the fact that the decolonisation process encompasses all aspects of being in the higher education space. The possibility, therefore, exists to be able to address both decolonisation of the curriculum and the principles of SD concomitantly by shifting the emphasis from what we teach and certain types of knowledge that currently dominate university curriculums to include how we teach for learning to occur (Padayachee et al., 2018). Decolonisation

for those engaged in decolonial praxis is “a repatriation of Indigenous land and life” (Tuck & Yang 2012, p. 21). However, Dastile and Ndlovu-Gatsheni (2013) argue that decolonial epistemic perspectives embody thinking that calls for the exploration of how a plurality of epistemologies can enrich and transform human experiences. The inclusion of relevant IK and Euro-Western epistemologies in the curriculum forms the basis of the way plurality of knowledges is embraced in my study.

In terms of education, decolonisation is linked to Le Grange’s (2016) vision for a decolonised curriculum based on an “emergent indigenous paradigm” that includes, among other constructs, “relational accountability” (curriculum is accountable to other humans and the wider environment), and “respectful representation” (curriculum creates spaces for “voices and knowledges of indigenous peoples”) (Le Grange, 2016, p. 9). When addressing decolonisation, it is important to differentiate between a larger movement like the ‘decolonial turn’ and specific contextual forms of decolonisation (Grosfoguel, 2013). The concept of "decolonial turn" brought about by Maldonado-Torres (2011) has been used to indicate the theoretical, artistic, and political relevance of a wide variety of positions in multiple geographical regions and fields of inquiry.

Decentring Western epistemology in university curriculums and designing them to involve socially distributed knowledge systems that are relevant to local and regional contexts are crucial (Le Grange, 2014, 2016). The call of decolonial scholars like Maldonado-Torres (2007, 2011), Ndlovu-Gatsheni (2015, 2017, 2018), Le Grange (2016, 2017, 2021), Heleta (2016), and Grosfoguel (2013) have driven the agenda for the decolonisation of education. Ndonga et al. (2020), Lotz-Sisitka (2017), Annan-Diab and Molinari (2017) and Padayachee et al. (2018) call for a more sustainable world through the use of education. The UN (2015), AU (2015), and the SA National Development Plan 2030 (National Planning Commission, 2015) have set the precedent for the aspired curriculum, especially in the SA context. These intersecting concepts form the nexus of my study

## **2.19 The need to Address ESD through a decolonial praxis**

The knowledge that was imposed on the colonised was largely unsustainable but had to be adopted by the colonised. Lotz-Sisitka and Lupele (2017) posit the need to consider various insights for ESD. The authors propose the need to emphasize ESD learning processes in conceptions of educational quality and, in turn, probe how such ESD learning processes are developed (Lotz-Sisitka & Lupele, 2017). The UN (2015) presents its sustainability and education agendas as blanket initiatives to improve the lives of people everywhere. Omer (2020) probes this notion further.

Omer (2020) believes that the language of “development,” in (SD now intersecting with “peacebuilding,” from (SDG 17) is a contemporary manifestation of the long history of European promises of salvation.

Eliciting methodologies of peacebuilding (like the SDGs) are not decolonial even if we agree with them (Césaire, 2000). What is unfortunate is that Africa still faces the need to solve mundane problems from the European point of view (Bartniczak & Raszkowski, 2019). Euro-Western countries controlling the sustainable development agenda in global South countries may lead to continued neo-colonial, this time under the guise of sustainable development (Omer, 2020). Nkrumah (1967) identified foreign defense and internal security, destructive military aid, and financial support to influence policies, as similar examples of neo-colonial practices that persist under the guise of peacebuilding treaties. Omer (2020) believes that the SDGs function as Euro-Western manifestations of development to promote peace. Africa at times seems to be addressing SD issues that emanated from and are rampant in Euro-Western contexts (Omer, 2020). Globally, Africa is the continent that produces the least amount of pollution but is held accountable to address the same SDGs in the same way as the mass polluters (Euro-Western countries) of the world (Bartniczak & Raszkowski, 2019).

The link between colonisation and SD is the congruent focus on Humanism (Omer, 2020). Humanism centres human importance often at the expense of the environment (Kruger, 2016), which is why I adopt a post-humanistic, post-abyssal approach in my study (to be discussed in Chapter Three). The SDGs although developed to help all nations are dominated by Euro-Western ideologies and implementations which therefore need a decolonial approach (Omer, 2020). The pillars of human development and social justice are deeply rooted in SDGs, these concepts set the precedence for decolonisation (Junior & Kokofele, 2019).

A curriculum that does not address SD will project an unsustainable existence (Heleta, 2016). It is therefore essential that the curriculum in SA reflects ESD through a multidisciplinary approach within the decolonial project (Lotz-Sisitka et al., 2017). A decolonised form of ESD is needed (Lebeloane, 2017). Paphitis and Kelland (2016) believe that ESD implemented by teachers in classrooms is necessary because this determines the type of future individuals that will be present in society. This is fundamentally a call to create and adopt a decolonised ESD model to address SD within the African and SA school curriculum to achieve longer-term SDGs. This study will propose models related to decolonised TPD (Figures 45 and 46) which integrates IK to address the SDGs in the SA school curriculum.

The exclusion of other knowledges (including IK) is what makes a curriculum colonised (Ndlovu-Gatsheni, 2018). A colonised curriculum could result in education for unsustainable development (unsustainable food production, unsustainable energy production, climate change, extinction of species, and epidemics) (Lotz-Sisitka et al., 2017). African people had their curriculum that was disrupted by colonisers (Kaya, 2013). Indigenous knowledge was declared illegal during colonisation, so this knowledge could not be practiced/ transmitted (Shizha, 2017). Lotz-Sisitka et al. (2021) argue for the need “to develop pedagogical praxis for development of intergenerational understandings, values, learners’ agency for change, and reflexive co-learning competencies situated within proactive, socially just and transformative sustainably-compatible development orientation”.

### **2.19.1 Decolonial African approach to ESD**

To journey across abyssal lines of thinking (de Sousa Santos, 2018), I sought to reclaim Southern voices in the teaching and learning of the SDGs in an African context. Blewitt (2018) notes that global debates about the meaning of SD sometimes involve contradictory discourses linked to differing starting assumptions and normative frameworks. I explore how the leveraging of IK and African IK may contribute to attaining ESD, which is relevant to the global South. Kaya (2013) acknowledges the emergence of a growing consensus among various stakeholders on the importance of African Indigenous Knowledge Systems (AIKS) for sustainable livelihood and development. Understandably, the notion of epistemic dominance by Euro-Western knowledge forms has diminished the human experiences of many African people. The constant epistemicide of African knowledge and AIKS has rendered colonial epistemologies an unchallenged, dominant truth (Kaya, 2013). De Sousa Santos (2018, p. 20) argues that “there is no room for philosophers conceived of as vanguard intellectuals, instead, the epistemologies of the South (including AIK) call for rear-guard intellectuals that contribute their knowledge to strengthening the social struggles against domination and oppression to which they are committed”. In the context of this study, teachers and IK holders of SA descent serve as the “rear-guard” intellectuals re-imagining and defending their epistemological freedoms.

Lotz-Sisitka et al. (2021) propose that in addition to strengthening the quality of ESD (and its certainties and uncertainties) there is a need to give coherent attention to emergent multi-, inter-, and transdisciplinary concepts such as societal transformations towards more sustainable futures within ESD. The form of ESD through redeeming of indigenous content and pedagogies which transcends the boundaries of being and non-being, natural and what is seen as unnatural was a

realization in this study. Research has long shown that the natural and conservative approach to knowledge from indigenous perspectives has contributed to SD (Lotz-Sisitka et al., 2021). Data shows that IK is relevant for SD (Das Gupta, 2011).

My study is a move toward re-discovering knowledge from a global South context in order to address ESD. This resonates with de Sousa Santos' (2018) expressions in his writings titled "Coming of Age of Epistemologies of the South". De Sousa Santos (2018, p. 16) focuses on the "production and validation of knowledges anchored in the experiences of resistance of all those social groups that have systematically suffered injustice, oppression, and destruction caused by capitalism and colonialism". Kaya (2013) proposes going back to our African ways to move forward. Kiti (2013, p. 2) contends that "as Africans, we can reformat our mind to face adequately the challenges of the contemporary world. Decolonisation in Africa is not possible without this new turn in the African mental universe." For Hountondji (1997), the "accuser's rhetoric" is nothing but "a subtle acquiescence in mediocrity". We need to struggle to become, to move from the periphery and become a centre among others (Kiti, 2013). Kaya (2013, p. 142) argues that "African scholars have not succeeded in empowering the continent to develop its own educational theoretical and methodological framework for knowledge production and SD". Dastile and Ndlovu-Gatsheni (2013) note that decolonial epistemic perspectives embody thinking that calls for the opening up of a plurality of epistemologies to enrich and transform human experiences. Ani (2013) supports this notion but expands on it by placing indigenous and intuitive knowledges as examples of Africa's epistemic pluralisation. I however leveraged IK as an African way of knowing in my study.

## **2.20 Decolonial implications for Science and Mathematics education**

Raju (2012) argues against the belief that science and mathematics are universal but were developed mainly in the West, the author believes that this thinking played a key role in the colonisation process. Science and mathematics are two of the most colonised subjects in existence (Raju, 2017). Studies by Heleta (2016), Jansen (2017), Ndlovu-Gatsheni (2018), Mudaly (2018a), and Subreenduth (2013) have highlighted the domination of the Euro-Western ideology in the SA curriculum, especially in the science and mathematics curriculums. Raju (2012) believed that false claims about the Western origin of hard sciences enabled the Westernization of education, and are still used to maintain it.

Joseph (1987) observed the false foundations of Eurocentrism in mathematics. Mudaly (2018b) maintains that to a large extent, most mathematics is taught in very unfamiliar contexts. The study

and exploration of mathematics did not begin in only Euro-Western contexts (Raju, 2012). Joseph (1987) highlights those discoveries of ancient mathematics written on papyri in Egypt and clay tablets in Mesopotamia, dating back to the second millennium BC, showing the origins of mathematics to have been present in other parts of the world long before Europe. Ndlovu-Gatsheni (2017) echoes that Africa and SA people are saddled with irrelevant mathematical knowledge that disempowers indigenous communities. Formal mathematics that is premised on its origins in Europe creates what Higgins (2014) calls 'slave mentality'.

Mudaly (2018a, p. 4) argues that the "science curriculum has been instrumental in promoting Euro-Western worldviews as universal". Raju (2017) posits that science education perpetuates colonial ideologies as the only truth in these disciplines, whereas other ways of understanding these subjects do exist. De Beer and Petersen (2016) believe that the decolonisation of the science curriculum should take a new perspective. Shumba and Kampamba (2013, p. 17) view science education as "a knowledge area and a process that is beneficial to society at large, and, as such, it must take its full share of responsibility for educating for sustainability thinking and action". Zidny and Eilks (2018) contend that science curriculums must be designed to represent a balanced perspective by exposing students to multiple ways of understanding science.

## **2.21 Education for Sustainable Development: Focus on Science and Mathematics**

### **Education**

Governments from both developed and developing nations are realizing that for their country to have a sustainable future, emphasis must be placed on the quality of science and mathematics education (UNESCO, 2017). Davis (2016) argues that teachers must be aware of the extent that what often pretends to be education can serve as a barrier to the development of critical thinking. The educational system of society must first be re-imaged (a reference to one of the stages of decolonisation proposed by Chilisa, [2012]) before such a society can experience a new and sustainable form of development (Uleanya et al., 2019). Uleanya et al., (2019) vehemently contend that the SA science and mathematics curriculum is not aligned with the SD demands of the nation, hence, the need for the curriculum to be revisited to ensure productivity and SD in society. Fadeeva et al. (2010) believe that teaching and learning about science and mathematics is of great relevance to SD. One of the ways that ESD can be instilled in learners and students is through the learning of science and mathematics (Ningsih & Juandi, 2019).

Sustainability and subjects like science and mathematics remain largely unconnected in the research literature (Renert, 2011). Mathematics (one of the subjects that will be addressed in this study) is popularly conceived as specialized. Mathematics is popularly conceived of as a pure body of knowledge and connections between global warming and the topics found in mathematics textbooks, such as fractions or quadratic equations, are not readily apparent (Renert, 2011). Pipere and Mičule (2014) call for a review of the mathematics curriculum for a sustainable future. Ismail (2017), who carried out a study at a SA university, observed that there was a lack of content related to SD in the science and mathematics Honours degree and she called for more content on this topic to be introduced.

There is a need for teachers and more especially science and mathematics teachers to engage with and in ESD (Lotz-Sisitka et al., 2017). Education, in general, can be seen as a vehicle to address SDGs but specific emphasis needs to be placed on science and mathematics education (Lotz-Sisitka et al., 2017). Lotz-Sisitka (2017, p. 34) argues that teachers in SA have a poor understanding of SD and cannot integrate sustainable development into classrooms. This study will be significant in creating some awareness and understanding of SD among science and mathematics teachers undergoing PD at a SA university. Science and mathematics may be considered subject areas that lend themselves most favourably to the inclusion of SD issues (Bentham et al., 2014).

An observation made by Bentham et al. (2014) within the science CAPS document especially was the almost complete neglect of ESD in both Grades 4 and 5, which they note as the fundamental years for the development of ESD skills and values. This is indicative of the emphasis placed on the subject across all grades (Bentham et al., 2014). Teacher education institutions should therefore draw on different cultural backgrounds and knowledge like indigenous and Euro-Western when training teachers. The practice of science and mathematics teachers within an Honours curriculum development module, informed by socio-cultural theories has the potential to enhance teachers' ability to deliver a sustainable inclusive curriculum (Mudaly & Ismail, 2013). Mudaly and Ismail (2013) further note that effective teacher training programmes can promote the epistemological decolonisation of African people by supporting them as they navigate new ways to bring IK into the mainstream of knowledge production in Africa.

There is a scarcity of research on decolonising content for ESD, especially in science and mathematics curriculums. Annan-Diab and Molinari (2017) emphasize the need for a more sustainable world where education is the driver. I address these paucities in my study.

## **2.22 Indigenous knowledge as a form of decolonisation**

There are many schools of thought about decolonising the curriculum. I adopt Chilisa's (2012) and Mignolo's (2011) stance on decolonisation which uses IK to address decolonisation. Pete et al. (2013) believe that the concepts of indigenizing and decolonisation are sometimes used interchangeably, but according to indigenous scholars and activists (see Alfred, 2009; Pete, 2015), they are separate but interrelated processes. The dismantling of relations of power and conceptions of valuable knowledge, through the revival and recovery of indigenous knowledge, has been a part of decolonial discourses, which are relational, contextual, and multiple (Mignolo & Walsh, 2018). The centring of a cultural practice located within IKS was a deliberate move towards decolonising the curriculum.

The definition of indigenous knowledge that is used in my study stems from African scholarship to further reflect the contextual understanding within my study. Abah et al. (2015, p. 668) define IK as the "local knowledge that is unique to a given culture and acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture." The notion of IK within my study needs to be understood with who the low voices (IK holders) are. The IK holders serve as sources of knowledge and insight. Indigenous knowledge holders according to McGill University (2021) are wampum belt holders, storytellers, artists, activists, hereditary leaders, or academics who have knowledge embedded within the cultural and epistemological worldview of indigenous communities that span generations. In the SA context, Govender et al. (2013, p. 157) believe that custodians of IK like "chiefs (amakhosi), headmen (izinduna), diviners-spiritualists (izangoma) and diviners-herbalists (izinyanga) can be seen as IK holders". The definition of an IK holder within my study draws on these definitions but is not limited to both McGill University's (2021) and Govender et al.'s (2013). Indigenous knowledge holders that teachers worked with were people who knew indigenous epistemologies and ways of knowing that were linked to a specific unit of work. Participants drew on the expertise of spiritualists, old and young, women and men from their communities as well as those defined by Govender et al. (2013) as custodians of IK. An IK holder in this study was not defined by Western conventions.

A holistic approach that respects the practices of IK holders and does not force these into Euro-Western scientific frameworks should be adopted (Shizha, 2017). Indigenous knowledge should be disseminated for the good of the community, for example, to improve people's livelihoods and health (Le Grange, 2016; Shizha, 2017). This understanding is directly related to the SDGs, especially SDG 3 - Good Health and Well-being, and SDG 8 - Decent Work and Economic Growth.

Through the centuries indigenous populations have developed specific techniques and technologies to carry out their activities in environmentally friendly and cost-effective ways that “ensure food security while conserving the diversity of wild and domestic plants” (Nakashima et al., 2012, p. 57). The focus on food security and the conservation of plant life directly links to SDGs 2, 12, and 15. Kaya (2013) notes that IK has close links to the natural world. The sustainable use of plants, care for animals and human beings, as well as equality between members of a community, are some of the values held by indigenous people (Kaya, 2013). Ndonga et al. (2020), Lotz-Sisitka (2017), Annan-Diab and Molinari (2017), and Padayachee et al. (2018) call for a more sustainable world through the use of education. The UN (2015), AU (2015), and the SA National Development Plan 2030 (National Planning Commission, 2015) have included SD objectives within policy briefs and curriculum statements (Tikly, 2019).

Opoku and James (2021) posit that recent debates on decolonising education in SA have traversed from the relevance of indigenous epistemologies in formal education curriculums to ‘how to teach’ indigenous knowledge in schools and higher education institutions. Some of the findings on how to teach IK that are relevant to my study were that :

the cultural villages of the local communities are to be toured to promote interaction between teachers, learners, students, and community members, especially the IK holders. The IK holders need to be invited and brought into the classrooms to teach the IK e.g., indigenous values and care for nature. The indigenous content taught, should not be done in isolation from the already westernized science taught in the schools but be infused and taught in an integrated manner and give more prominence and emphasis to the indigenous epistemologies (Opoku & James, 2021, p. 14).

The use of IK to teach science and mathematics has great implications for the sustainability of planet earth (Martin et al., 2019). Lotz-Sisitka et al. (2017) believe that the focus in this endeavor needs to shift to TPD if ESD is to be realized in SA. The use of IK in the form of puppetry, indigenous games, or even folktales to teach science or mathematics as teaching methodologies, addresses the dual border-crossing between Euro-Western knowledge and AIK (Cronje, 2015), and between sustainability and education (Petersen & White, 2018). This process has to begin with the capacitation of teachers in the form of professional development (Tikly, 2019).

Webb (2014) notes that learners may opt out of valuing school science due to them feeling alienated and discomfort caused by clashes between their traditional worldviews and Euro-Western scientific

worldviews. What is indigenous is not considered as a true science but rather a pseudo-science (Zinyeka, 2016; Grosfoguel, 2013). Hodson (2009) and Webb (2014) argued for the need for teachers to acknowledge the prior knowledge, conceptions and worldviews of learners to address dwindling interest in school science. The lack of acknowledgement of different knowledges makes it difficult to address issues of IK and sustainable development, when these two concepts generally work hand in hand (Hodson, 2009). McDonald (2017) notes that teachers being consistent with the 'nature of science' they teach means being responsive to divergent beliefs and traditional views that learners may hold. Resistance to this may lead to teaching an unsustainable curriculum which rejects alternative knowledges. In many schools in South Africa, IK and science integration has been largely left to the discretion of teachers (Moyo, 2011), who have not received the support they need.

Khupe (2014) argues that a lack of consensus about IK in communities have made it difficult for it to be leveraged into the curriculum. Some people in communities believe IK is tantamount to witchcraft whereas others believe these are not the same. Integrating IK into a community with such divergent views becomes difficult. The effectiveness of the process of identifying IK hinges on the extent to which it is aligned to, and is sensitive to the worldviews of participants (Chilisa, 2012). One of the main reasons that IK is difficult to integrate into the curriculum is that, IK in South Africa is barely documented, so the teacher has few sources to draw from (Otulaja et al., 2011).

Another difficulty in integrating IK into the school science and Maths curriculum is the vast differences between the two. Zinyeka (2016, p. 266) notes the following differences between IK and school science especially:

Science is concerned with testable phenomena and it considers the universe as knowable "Also while science attempts to describe, explain, predict and control phenomena" whereas "IK embraces both testable and non-testable metaphysical phenomena" as it considers some aspects of the universe as strange. Indigenous knowledge attempts to describe, explain, predict and control phenomena as well as harmonize with phenomena and incorporates mystery in its explanation of the universe.

Furthermore, school science is in written form and is taught in an abstract context (Kibirige & Van Rooyen, 2007). Generally IK is orally and experientially transmitted and is learnt through hands-on-experience (Kibirige & Van Rooyen, 2007). The epistemologies of IK are not specifically stated which necessitates a better interrogation of IK epistemologies (Ogunniyi, 2011). Science is based

largely on a mechanistic and reductionist worldview (Ogunniyi, 2011); mainstream science tries to understand systems as isolated parts (Kibirige & Van Rooyen, 2007), IK is based essentially on an anthropomorphic, pluralistic and holistic worldview (Ogunniyi, 2011). Modern science sees the universe as being knowable science attempts to eradicate mystery and further that the basis for validating science is essentially its predictive validity. Webb (2014 p. 4) notes that IK sees the universe as mysterious IKS values co-existence with the mystery of nature and celebrates this mystery” and further that the basis for validating IKS is its use over a long period of time (Webb, 2014 p. 4).

### **2.23 Teacher Professional Development and Teacher Learning**

There is a need for teacher professional development (TPD) programmes to address issues of transformation (focused on curriculum decolonisation) and SD using IK in the classroom. Higher education institutions are settings where this should occur (Lotz-Sisitka, 2017). The ‘knowledge mix’ (of IK and ESD) is fundamentally transforming the structuring and content of teacher education qualifications in SA at present and is particularly significant to this initiative (Lotz-Sisitka, 2017). Singh (2011) highlights the sporadic nature of TPD in the country and believes that the quality of teachers who understand SD in SA has diminished. Lotz-Sisitka (2017) argues that teachers have little capacity for integrating SD into teaching and learning. Lotz–Sisitka et al. (2017) highlight the need for research to analyse the professional development of teachers in South Africa. Teacher education can drive SDG 4 implementation through curriculum innovations and professional development to enhance education quality and relevance (Lotz–Sisitka et al., 2017).

Tooley and Connally (2016) posit that effective professional development allows teachers to actively implement what they learn. Modelling decolonisation and ESD into curriculum conversations assisted in how these were addressed in my study. Bentham et al. (2014) offer a table that integrates the ESD principles categorically, which she developed through an analysis of literature and major policies on ESD.

**Table 2**

***An ESD analytical framework for Teacher Education related policy***

<b>Categories of ESD-related themes</b>	<b>Sub-categories of ESD-related themes</b>
<b>ESD Teaching and Learning Approaches (TL)</b>	<p>Development of Action Competence (AC)</p> <ol style="list-style-type: none"> <li>1. Participation in decision-making and community-based decision-making (Eg. Debates and action plans).</li> <li>2. Active learning approaches regarding Sustainability issues.</li> <li>3. Learner-centered approaches.</li> <li>4. Engagement in community and social development activities.</li> <li>5. Participatory and collaborative learning activities.</li> </ol>
<b>Alternativ Knowledge Systems approach to sustainability (AK).</b>	<ol style="list-style-type: none"> <li>1. Considers different knowledge systems as an important starting point for exploring issues of sustainable development.</li> </ol>
<b>ESD Skills (S)</b>	<p>Critical and Creative thinking (CC)</p> <ol style="list-style-type: none"> <li>1. Explores ways of solving local contextually relevant problems.</li> <li>2. Considers society, economy, and environment while problem-solving.</li> <li>3. Carries out critical analyses of current knowledge and situations and their implications for future decisions.</li> </ol>

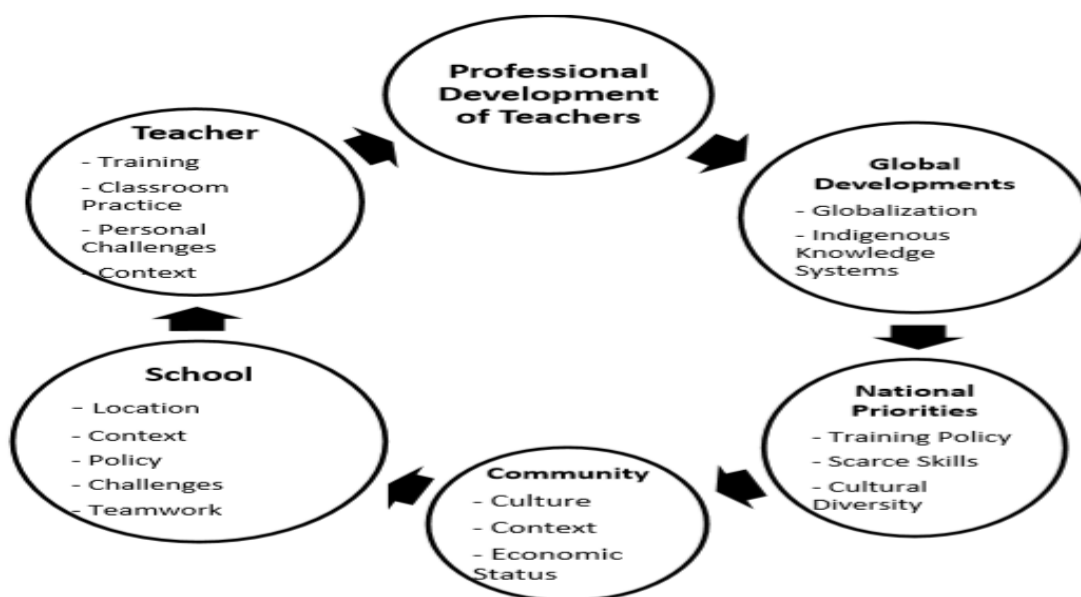
	<p>Systemic thinking (ST)</p> <ol style="list-style-type: none"> <li>1. Engage in looking for links to solve complex problems.</li> <li>2. Understand that systems are complex that usually involve more than the sum of their parts.</li> <li>3. Engaging in partnership building to address needs and solve problems.</li> </ol>
	<p>Future thinking (FT)</p> <ol style="list-style-type: none"> <li>1. Recognizing the need for change.</li> <li>2. Searching for a way to attain a sustainable future.</li> <li>3. Understanding the short and long-term effects of current decisions.</li> <li>4. The importance of renewing knowledge about evolving sustainability theory and models.</li> </ol>
<p><b>ESD Knowledge Competencies (KC)</b></p>	<ol style="list-style-type: none"> <li>1. Promotes an understanding of various sustainability issues both local and global E.g., Food security, economic and social justice, democracy, distribution and use of resources, etc.</li> <li>2. Promotes an understanding of how society, the economy, and the ecological environment play a part in these sustainability issues.</li> <li>3. Promotes the sustainable use of and care for natural resources.</li> <li>4. Promotes the understanding that all disciplines can explore ESD through their subject knowledge.</li> <li>5. Connects relevance of subject knowledge to society, environment, and economy.</li> </ol>

<b>ESD Values (V)</b>	<ol style="list-style-type: none"> <li>1. Promotes environmental stewardship.</li> <li>2. Promotes social tolerance and equity.</li> <li>3. Promotes collaboration in decision-making and problem-solving.</li> </ol>
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(Bentham et al., 2014)

In terms of Table 2, Tikly (2019) argues that Teaching and Learning Approaches, ESD Skills, ESD Knowledge Competencies, and ESD Values need to be related to teachers' specific teaching contexts and not be generalized. The teaching context within my study is the South African, decolonial context. Lotz-Sisitka et al. (2017) herald the processes of professional development that are contextual yet relevant to the ESD project. In an African context, Lebeloane (2017) believes that these professional development practices should equip teachers with the skills to draw on indigenous knowledge. Singh (2011) provides a model for teacher professional development integrating the necessary skills which are shown in Figure 10 below.

### 2.23.1 Model for Teacher Professional Development (TPD) linking to ESD



**Figure 10: Model depicting effective professional development (Singh, 2011, p. 1634).**

All aspects within this model are important as they pertain to TPD and current, global as well as local aspirations. I draw attention to the aspect of “Global Developments” where the focus is on the use of IKS, the focus on “National Priorities” one of which is the National Development Plan 2030,

Agenda 2030, and the emphasis on “Community”. These are important, especially for the decolonial projects and to address SD in SA within teacher education institutions. Designers of professional development programmes should incorporate aspects of modelling (demonstration) so that teachers gain an understanding of the new practice and the content of the professional development programme must be specific to that subject and not be generic in any way (Singh, 2011).

Pedagogy according to Barton et al., (2019) describes the study of teaching, and how content is presented and delivered to a learner. It is the creation of an educational process that leads to knowledge gain in the learner (Barton et al., 2019). Pedagogy is central to education and the lives of both teachers and learners (Singh, 2011). Seminal scholar, Shulman (1987) believes that the pedagogy adopted by teachers shapes their actions, judgments, and other teaching strategies by taking into consideration theories of learning, understandings of students and their needs, and the backgrounds and interests of individual students. Science and mathematics education could be decolonised from various approaches but what is important to my study is a pedagogy that embraces the needs of society.

Kwon et al. (2017) proposed their three-stage practice-oriented group framework for teachers and teacher education institutions, which I have adapted to use within my study. I adopted Kwon et al.’s (2017) model which was developed in Korea (a country similar to SA in that it was historically colonised by Japan). Using a model developed in Asia is in keeping with my positionality for embracing an inter-cultural epistemological approach to teacher professional learning and research. The processes and stage progression of TPD are adapted to form the framework below (Figure 11 below), taken from an international context to suit a local SA context reflecting the decolonisation approach I use in this study (which is using both local and foreign knowledge). These three stages describe my study.

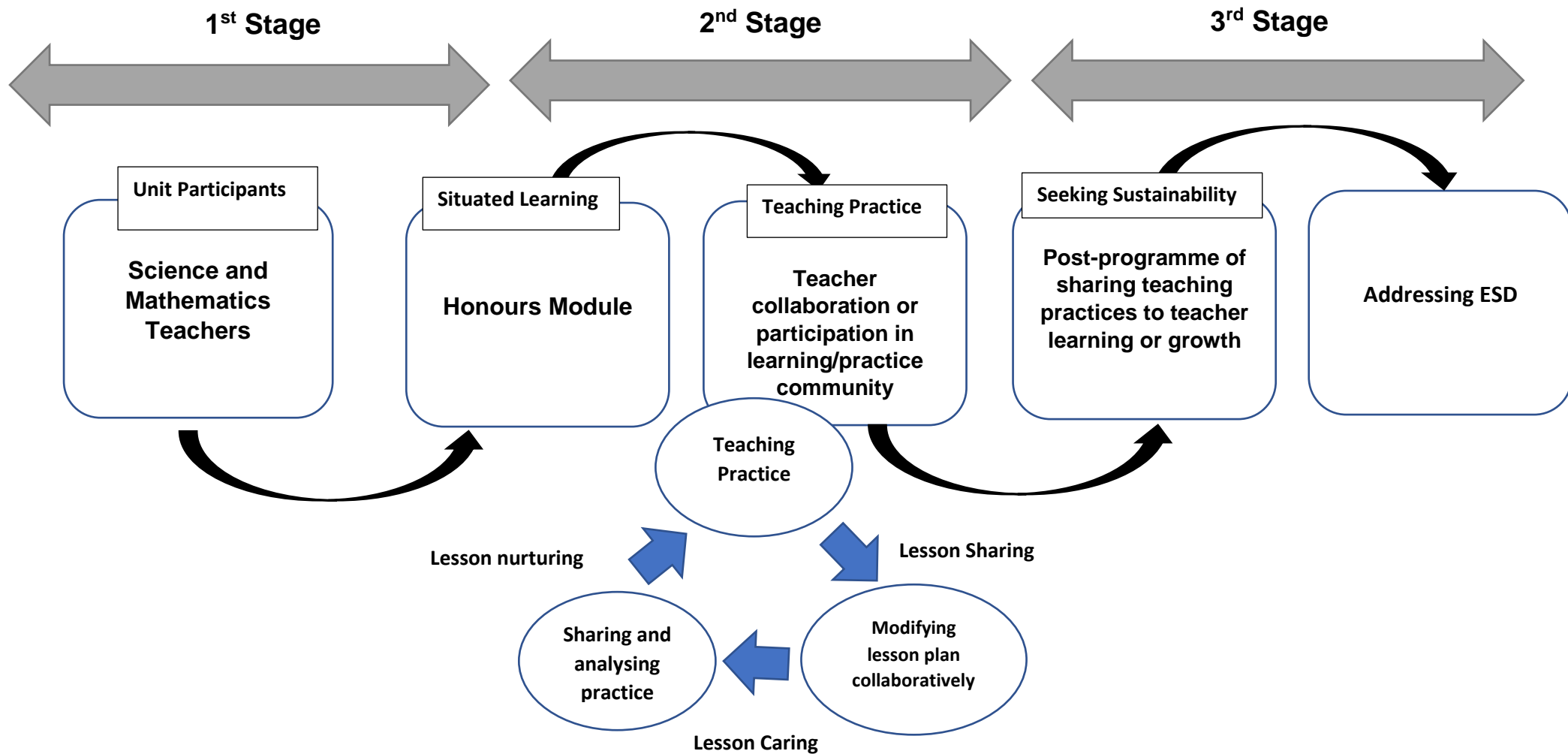


Figure 11: Three-stage Practice-oriented framework for teachers (Adapted from Kwon et al., 2017)

I applied this model in the following way: The first stage looked at orientating teachers and their engagement with the Honours module which was a situated learning context. The second stage focused on the development of lessons and lesson sharing, caring, and nurturing (teacher group presentations). This second stage encompassed the deconstruction and reconstruction of units of work from the science or mathematics curriculums. The third stage focused on knowledge sharing and engagement in a whole class setting where knowledge dissemination occurs. The third stage allowed the PD process to extend beyond the HEI and into the classrooms in which the teachers taught. Teachers may use the knowledge and information they gained from stage three in their own practices. The focus of my study is on teacher knowledge related to ESD which is a nascent research area (Lotz-Sisitka et al., 2017).

Chilisa's (2012) stages of decolonisation can be matched here. Commitment will inform all three stages. The first stage will encompass mourning and discovery. The second stage links to dreaming. The third stage will be based on action. These stages will be discussed in the Theoretical Framework section. This framework will allow me to make the relation between the groups of teachers and how teachers learn, then implement the curriculum based on this learning, which is the crux of my study. The distinction between Kwon et al.'s, (2017) framework and the one I adopt is in terms of the participants, curriculum, context, and methods to reflect a SA context. The processes and stage progression can be understood to be similar. This framework will allow me to make the relation between the groups and how teachers learn, then implement the curriculum based on this learning within a group.

### **2.24 Gap in the literature:**

The paucity of literature is based on the lack of IK-related, locally relevant contributions to SD set out in Agenda 2030 (Lotz-Sisitka et al., 2017). There is also a lack of practical examples at teacher education institutions to show how education for SD can be integrated into teacher education (Lotz-Sisitka et al., 2017). The paucity of coherent literature that documents the achievements, challenges, and prospects of SD on the continent reinforces the skepticism about achieving SD in Africa (Ndonga et al., 2020). This study seeks to add meaning and some clarity to the SDGs in the SA education context. Lotz-Sisitka (2017) notes that decolonisation is an important, under-explored concept in sustainable education, which this study seeks to explore. My study first addresses a contextual and methodological gap. Lotz-Sisitka et al. (2017) note that there is a lack of studies on teacher education that focuses on ESD on the African continent especially. I address Lotz-Sisitka's concerns by conducting this study in a global South context, adopting a democratic participatory

research design, through the decolonial and *Ubuntu-currere* lenses while exploring how teachers engage in PD and ESD curriculum development with IK holders.

Based on the literature that I reviewed, several researchers, including Lotz-Sisitka (2017), Annan-Diab and Molinari (2017), Ndonga et al. (2020), and Subreenduth (2013) identify a lack of decolonised discourses about marginalized indigenous knowledge in South Africa, especially in ESD. There is a scarcity of research on decolonising content for ESD, especially in science and mathematics curriculums for schools in South Africa. Annan-Diab and Molinari (2017) emphasize that the need for a more sustainable world was acknowledged by UN members in 2015, when 17 SDGs were set, which positioned education at the heart of the strategy to promote SD. These are the paucities that I will address.

## **2.25 Conclusion**

The chapter on the review of literature covered a myriad of intersecting components that reflect what this study seeks to explore. A discussion of SD and ESD with a focus on the African continent and issues of decolonisation was presented. I also highlighted the decolonial approach to SD relevant to my study by relating this to IK and its relation to the curriculum in the SA context. The link between IK, SD, and science and mathematics education was discussed to explain the positionality of my study within the literature. The specific focus on TPD took my discussion in this chapter to explore issues of teacher learning and teachers implementing pedagogical practices by putting forward a model that I used to guide my study which was Kwon et al.'s (2017) "Three-stage practice-oriented framework for teachers" (Figure 11). In the next chapter, I present theoretical constructs which underpinned this study.

## **Chapter Three**

### **Theoretical Framework**

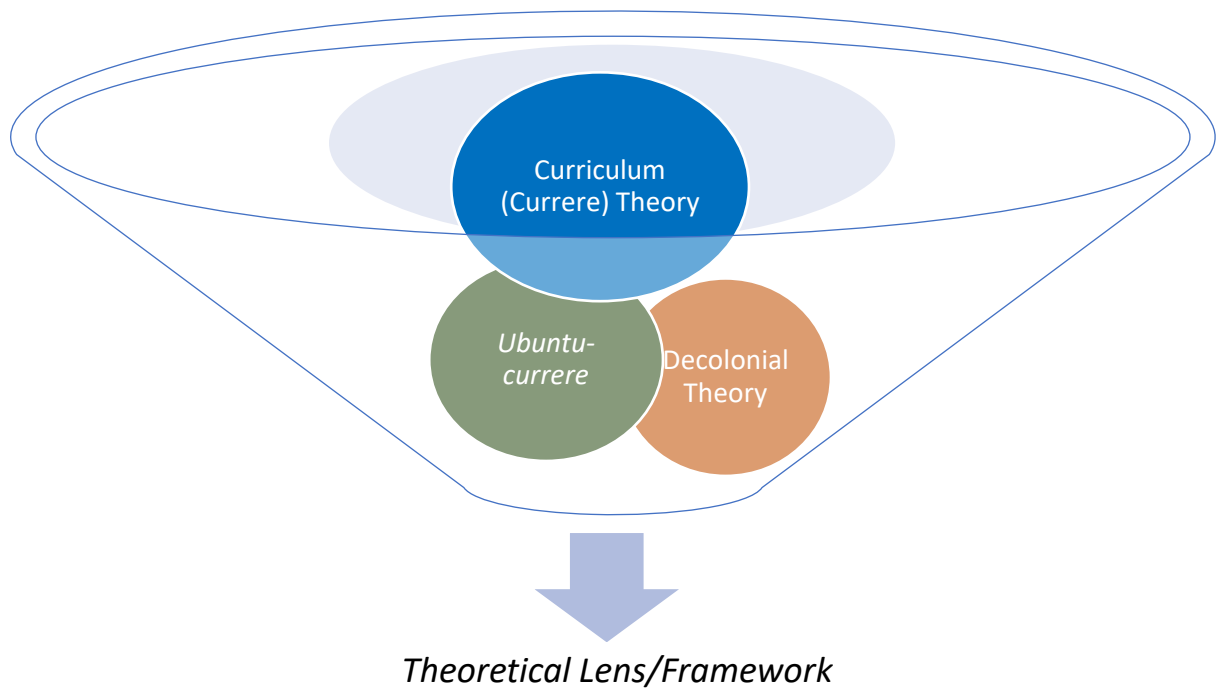
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### 3.1 Introduction

I adopt a decolonial lens and imagine possibilities for the university curriculum, based on understandings of ontological, epistemological, and methodological positioning within the relational paradigm revival of decolonial debates, as they have implications for university and school curriculums in Southern contexts. There were two key theories in my study, namely, curriculum and decolonial theories. These two overarching theories link with other constructs leveraged in my study and therefore informed the theoretical lens I adopted. The philosophical framework used in this study has vital implications for the academy in an African context. The theories adopted in my study were also a combination of constructs conceptualised both on the African continent and Western context. In this way, the theories used reflected the approach of using African and Euro-Western epistemologies in keeping with my valuing of a plurality of knowledge which informs my understanding of the decolonial praxis. The problem of the lack of engagement with SD in the curriculum by teachers, the DBE, and HEIs in the African context (Padayachee et al., 2018) coupled with the coloniality of the SDGs and global SD initiatives has led to the selection of the theories I adopted.

The overarching theory used in this study is the Curriculum theory (CT), mainly because decolonisation of the science and mathematics curriculum, as a part of the TPD, was what drove this study. An understanding of the curriculum within a specific context is important if a form of curriculum transformation, decolonisation, or SD address is to be realized (Lebeloane, 2017).

The decolonial theoretical lens was adopted based on insights from Ndlovu-Gatsheni (2015, 2018), Maldonado-Torres (2011), Grosfoguel (2012, 2013), Smith (1999), Le Grange (2016, 2018) and Chilisa (2012). The 'reconceptualised curriculum' is particularly relevant in a SA context which is the locus of this study. The concept of '*ubuntu*' which is linked to decolonisation through indigenization (Ndlovu-Gatsheni, 2015), is an indigenous Bantu ideology (Oelofsen, 2015). This was used to inform the reconceptualised curriculum in the form of the *Ubuntu-currere* proposed by Le Grange (2014). The *Ubuntu-currere* is the type of (global South) curriculum theory my study leverages. I also draw on constructs from the decolonial theoretical (also informed by global South thinking and linked to the *Ubuntu-currere*) understanding specifically to the SA context where the call for decolonisation extended specifically towards the decolonisation of the curriculum. Below is a diagram (Figure 12) that I developed of how intersecting theories informed my theoretical lens.



**Figure 12: Development Process of Theoretical Framework**

The theories I selected to inform my study enabled me to understand how science and mathematics teachers could engage with ESD (Padayachee et al., 2018), and be able to integrate sustainable development in classrooms (Lotz-Sisitka, 2017), through curriculum decolonisation. I, therefore, saw the importance of understanding the meaning of curriculum.

### **3.2 Curriculum studies**

The curriculum in an African context according to scholars (like Ndlovu-Gatsheni, 2015, 2018; Smith, 1999; Le Grange, 2016, 2018; Chilisa, 2012) is more than a collection of material and theoretical knowledge sources. I concur with the notion held by Tedesco et al. (2014) that the curriculum is the outcome of a process reflecting a political and societal agreement about the nature of education for the desired society of the future. The type of curriculum used within a society will define the individuals within that society (Holmes & McLean, 2018). Behaviours, values, and actions are defined by the curriculum (Holmes & McLean, 2018). In order to achieve SDGs, education is required, and that could begin with a reconceptualized curriculum, therefore, a curriculum based on ESD becomes necessary (Tikly, 2019). Curriculum studies according to Apple (2019, p. 162) should focus on specific questions like:

Whose knowledge is this? How did it become “official”? What is the relationship between this knowledge and how it is organized and taught and who has cultural, social, and economic capital in this society? Who benefits from these definitions of legitimate knowledge and who does not? What are the overt and hidden effects of educational reforms on real people and real communities? What can we do as critical teachers to challenge existing educational and social inequalities and create policies?

These questions are pertinent to the African context, especially considering that the curriculum has often reflected Euro-Western values whilst omitting indigenous and African ones (Molefe, 2016). In the SA context, curriculum change needs to be informed by decolonial praxis which should embrace indigenous epistemologies (Ndlovu-Gatsheni, 2015).

### **3.3 Curriculum theories**

Curriculum theory is an academic discipline devoted to examining and shaping educational curriculums (Pinar, 2012). Holmes and McLean (2018, p. 21) believe that “curriculum theory is fundamentally concerned with values and theorizing about the curriculums of the future”. A future in the SA context that is based on sustainability and progress, free of colonial domination should begin with how curriculums are viewed (Lotz-Sisitka et al., 2017). Embarking on a decolonised teaching and learning experience which incorporates AIK and other IK into what is largely seen as an educational system disproportionately built on Euro-Western ideologies was important in my study.

Curriculum theory testifies to the progressive insistence that education has value for society and the “self” (Dewey, 1916). The UN (2015) acknowledges that education plays an important role in a sustainable future for all. The use of schooling and the curriculum to actively create sustainable identities with care for society and the natural world is a necessary objective for all educational exercises (as it is in my study) (UN, 2015).

The CT in this study was adopted within the context of teacher professional development (TPD) as well as the diverse SA context. Mudaly and Ismail (2013) note that the practice of science and mathematics teachers within an Honours module informed by theory has the potential to enhance teachers’ ability to deliver a sustainable inclusive curriculum. Mudaly and Ismail (2013, p. 22) further note that “effective teacher training programmes can promote the epistemological decolonisation of African people, by supporting them as they navigate new ways to bring IK into the mainstream of knowledge production in Africa”.

### 3.3.1 Reconceptualised curriculum

The specific curriculum theory used in my study is a form of reconceptualised curriculum. I lean on Pinar's (2012) conception of the reconceptualised curriculum because it includes not only instructional materials used in the curriculum but also includes the experiences (in keeping with my exploratory study) that those materials hope to mediate. The notions of reconceptualised curriculum aim to meet learners where they are and fold relevant and meaningful elements of learner histories and their professional futures into a contextualized present wherein, they have domain-related experiences of their co-creation (Pinar, 2012). Domain-related experiences mean having significant experience and knowledge about how the curriculum links to society (Pinar, 2012). In this study, it means relating knowledge of SD from the curriculum to lived experiences.

Pinar (2012) believes that the curriculum in any context can only be developed once there has been the process of curriculum reconceptualisation. Any development of the curriculum premised on outdated and non-societal outcomes is futile (Pinar, 2012). Magrini (2016) views the reconceptualised curriculum as "reconceptualising and re-configuring a view to the education curriculum, and the teacher-pupil relationship in the age of standardized education." Huebner (1990) in his seminal work on curriculum re-conceptualisation, posits that a continued reconceptualisation of curriculum is about changing the way we think "about" our educational practices. One way in which our thinking about the curriculum can change is through exploratory praxis and scholarly engagement (Magrini, 2016). Huebner (1990) asserts that the formulation of new concepts which are pertinent to the reconceptualised curriculum will come from future curriculum research and theorizing. My study is one such research where teachers' interpretation of the curriculum, decolonisation, and how the SDGs could be addressed through the curriculum are privileged. Epitomizing Pinar's (1978) reconceptualisation is the notion of *currere*, a self-analysis of educational experiences, an ongoing, complicated conversation with oneself as the private intellectual, which allows for growth and interaction with the public sphere of pedagogy (Pinar, 2012).

### 3.3.2 Currere

Currere means to run a course which is what curriculums are (Pinar, 2012). The substituting of the Latin verb form *Currere* (to run) in place of the normative form of *the curriculum* (referring to a racecourse) opened the curriculum field to questions beyond a focus on organizational issues of curriculum design and development (Pinar, 2012). This allowed curriculum developers to consider

more basic questions of culture, society, and the place of education in the running of personal and collective lives (Pinar, 1978).

Currere according to Pinar (2012) is a complicated concept due to the variation in societies and individuals. A curriculum that recognizes variations must be valued (Le Grange, 2014). The curriculum should have links to society and the way we as people live. Wallin (2010) contends that currere is a worldview. Wallin (2010, p. 2) further elaborates on currere:

[To] run implies that the conceptual power of Currere is intimate to its productive capacity to create flows, offshoots, and multiplicitous movements. For example, the 'running' roots of bulbs and tubers extend to create new interfaces with other organic and non-organic bodies, extending the experience of what a body can become.

Regarding the curriculum, sustainability and SD need to extend past the confines of documents and policies. It should penetrate the classroom and lives of people if SD is to become real (Padayachee et al., 2018). This influences whether learners will become unsustainable individuals focused on technological advancements and Industrial revolutions (IRs) or individuals focused on SD while undergoing IRs and technological advancements (Kasa, 2017). The adoption of Currere as discussed by Wallin (2010) guided my study and allowed me to understand how the specified curriculum can be understood as the lived curriculum. The education of today impacts the kind of future we have, that future is defined by how learners develop and who they become in the world (UNESCO, 2015). This in turn can create alternative views of the curriculum (Pinar, 2012).

### **3.3.3 Currere (Curriculum) as Autobiographical method**

Le Grange (2021) a South African, sustainability and science curriculum change researcher links the process of self-determination to Pinar's (2012) Euro-Western conception of "currere" in an ideology which Le Grange (2021) calls 'curriculum as Autobiographical method'. Self-determination entails self-criticism and depicts the beginning of the individual's efforts to rid the self of the shackles of coloniality (Le Grange, 2021), in this case, curriculum coloniality. The curriculum as an Autobiographical method and self-determination culminates in what I call 'Teacher Agency'.

The reconceptualised curriculum focuses on bringing society closer to the school (Pinar, 2012), whereas the understanding of the curriculum as an Autobiographical method seeks to bring the lived experiences of individual teachers and learners to the classroom (Le Grange, 2018).

Individuals make up society, therefore Le Grange (2021) offers the view that curriculum as an Autobiographical method considers individual and collective experiences within the curriculum development processes. The idea of *currere* as a form of decolonisation resonates with Ndlovu-Gatsheni's (2018) contention that decolonisation requires self-unlearning, in order to relearn.

Alternative views of the curriculum such as: "the stories learners are told about their past present and future; curriculum-as-lived, hidden and null curriculum; and the active conceptual force of *Currere* open up possibilities for decolonising the university curriculum" (Le Grange, 2018, p. 15). Le Grange (2021) offers a model which takes into consideration these aspects when dealing with the curriculum from Pinar's (1978) perspective, in what is known as a curriculum as an Autobiographical method. The earliest expressions of the Autobiographical method can be traced to a series of writings titled "Working from Within" (Pinar, 1978). Pinar writes: "Like some modern painters, my students and I have come to feel that we rarely need to refer to subject matter outside ourselves. We work from a different source. We work from within" (Pinar, 1978, p. 331). The lived curriculum gains momentum in this understanding whereby we understand what we learn to largely influence the way we live (Le Grange, 2014). I draw on the idea of autobiography because teachers in my study incorporated IK which they and their learners were familiar with (from their homes/communities) to develop a unit of work from the curriculum.

### **3.4 *Ubuntu-currere***

Le Grange (2019, p. 13) proposes an "alternative way of understanding a curriculum that links the African construct *ubuntu* with *currere*". Le Grange (2016) argued for an *Ubuntu-currere*, a construct distinctly from the South, to re-imagine a curriculum that transcends fixed boundaries. *Ubuntu-currere* promotes the ideologies of *ubuntu* such as the connection of oneself with other humans and the non-human environment (Le Grange, 2016). Southern thinking involves inviting others to venture into the unfamiliar intellectual world to broaden their epistemic horizons (Takayama, 2016). Southern thought involves exploring alternative research methodologies in and for education (Takayama, 2016). Le Grange introduces the concept of *Ubuntu-currere* (Le Grange, 2016), which transcends restrictive boundaries and promotes creativity in a way that enables a sustainable union of individuals with humans and the environment.

The understanding of relational accountability is crucial when one reflects on current global concerns *Ubuntu-currere* means framing a pedagogy that can respond to the clarion call for South African higher education's transformation in reconceptualising varied voices as premised on

democratic thought (Le Grange, 2019). Le Grange (2016, p. 9) proposed “relational accountability” as “an “emergent indigenous paradigm” whereby the curriculum is accountable to the environment and all people”. The *Ubuntu-currere* is a take on what de Sousa Santos (2018, p. 28) identifies as a concept from the “epistemologies of the South which outlines a framework for challenging the dominance of Eurocentric thought.”

In SA, the particular instantiation of the concept of *ubuntu* (I am because we are) needs to be reflected in the SA curriculum (Oelofsen, 2015). A decolonised curriculum is “evidenced by a shift in subjectivity from the arrogant ‘I’ (of Western individualism) to the humble ‘I’ – to the ‘I’ that is embedded, embodied, extended and enacted” (Le Grange, 2014, p. 9). The ‘I’ represents more of a collective, both human and non-human, it encompasses the natural world, which directly links to the environmental pillar of SD. *Ubuntu-currere* focuses on democratic interactions (Le Grange, 2019).

Smith (1999) argues that democratic interactions should reflect arguments around IK and place emphasis on democratic participatory interactions. In the context of my study, democratic participatory interactions were based on interactions within the groups that will be made up of teachers studying an Honours module and IK holders. The inclusion of the IK holders in this study fulfilled Smith’s (1999) sentiments of reflecting IK within democratic participatory interactions, and the democratic participatory research design I adopted. This design choice was influenced by the theories I used, one of which was the *Ubuntu-currere*.

Most of the dimensions that *ubuntu* underpins in SA, directly or indirectly contribute to the sustainability of people and the country (Oelofsen, 2015). *Ubuntu* corresponds to respectful representation in Le Grange’s (2018) *Ubuntu-currere*. According to Le Grange (2018, p.9) “all groups present in society, their epistemologies, and their pedagogical practices should be considered, respected, and accepted with kindness”.

An “*Ubuntu-currere*” (also termed united curriculum) according to Le Grange (2016, p. 9) could enable the unity of people with their environment. Le Grange’s (2016) sentiments are deeply rooted in the notion of combining different knowledge for a better life. Contesting knowledges was Euro-Western forms of knowledge that already exist in the SA science and mathematics school curriculums and the IK teachers in my study sought to leverage. Contesting knowledges according to Shay (2015) refer to the knowledge within the curriculum that had always been seen as valuable and included co-existing with the knowledge that was historically viewed as not valuable and

excluded. The inclusion of contesting knowledges within the curriculum opens spaces for knowledge interrogation, questioning, inclusion, and redefinition (Shay, 2015). Breidlid (2013) proposes the use of contesting knowledges for a more sustainable future.

Le Grange (2019) posits that the *Ubuntu-currere* shifts our register of reference away from the individual human being to an assemblage of human-human-nature. This concept promises to counteract the manifestations of the crisis of humanism such as racism, sexism, homophobia, xenophobia, environmental destruction, and centrally controlled and standardized education systems (Le Grange, 2019). Research grounded in humanism is restricted to human-driven interactions (Kruger, 2016). It is argued that crises are manifestations of negative power, potestas that produce currere's reactive force (Le Grange, 2014, p. 222). However, a framing of what is central to the decolonisation of the curriculum as well as how it could be done was necessary for my research.

My study leans more towards a posthumanism worldview (as previously stated in Chapter Two), "as it offers an opportunity to think about research practices in terms of transversality" (Kruger, 2016, p. 83). Colebrook (2014, p. 249) argues that "research orientated solely towards the welfare of the human (humanism) cannot address the challenges faced in the Anthropocene. These challenges include climate change, species extinction, ecological depletion, mass migrations, and increased racial intolerance". Posthumanism according to Kruger (2016, p. 88) "challenges one to let go of an ethics grounded in universal humanism when conducting research and to move towards an immanent and relational ethics". These ethics relate to the human and the non-human world which links to the environment.

Building on the work of Le Grange (2016, 2019), Hlatshwayo et al. (2020) posit *Ubuntu-currere* as an emancipatory alternative to the traditional top-down, hierarchical approach to curriculum design and teaching through research and community engagement. The authors argue that "curriculums can be thought of as an active conceptual tool that is dialectical, inclusive, and democratic in its very constitution, capable of enabling varied voices such as those from students and community stakeholders (like IK holders)" (Hlatshwayo et al., 2020, p. 1). Hlatshwayo et al. (2020) further offer "moments of *Ubuntu-currere* enactment" which emanated from their study conducted within the higher education context. Below are two of these "moments" which informed my study. The first moment discussed by (Hlatshwayo et al., 2020, p. 23) was:

A collaboration that *is* conceived within a framework of *Ubuntu-currere* as it provides an engagement with values of solidarity, compassion, respect, and dignity that encourage tolerance and survival of humanity and is useful in conceiving and enacting social justice.

In the context of my study, this moment was addressed by including IK holders, their views and values as well as their knowledge of IK and SD. Groups of teachers engaged community members (who served as IK holders) as sources of knowledge who contributed vital IK to units of work that teachers chose from either the science or mathematics curriculum. The second ‘moment of *Ubuntu-currere* enactment’ as proposed by Hlatshwayo et al. (2020, p. 31) was “challenging the notion of the epistemic othering of IK”. Hlatshwayo et al. (2020, p. 28) state that “challenging epistemic othering of IK as an imagined moment of curriculum enactment in higher education curriculums do not necessarily promote the epistemic rejection of Western knowledge systems, but rather motivate for epistemological diversity in curriculums.”

Leveraging IK within the science and mathematics curriculum which has historically been Euro-Western dominated creates a new appearance of the curriculum. The reconstructed model of units of work presented in my study contained Euro-Western ideologies (present in the science and mathematics curriculum), IK leveraged by teachers, and ESD (in which knowledge of the SDGs would be addressed). This reconstruction is in opposition to the marginalization of IK, which in the past included various voices and addresses of social justice through democracy. My study sought to retrieve the marginalized voices of IK holders as a way of challenging the epistemic othering of IK.

The concept of *Ubuntu-currere* according to Hlatshwayo and Shawa (2020) is useful in imagining context, difference, and cosmopolitan perspectives in mapping the purposes of higher education in SA. The SDGs and ESD are largely seen as ‘Common Good projects’ but within the African context these need to be explored within, which means navigating issues of colonisation of knowledge and synchronization of the curriculum (Omer, 2020; Padayachee et al., 2018). The inclusion of the IK holder and IK itself within the curriculum allowed an in-depth exploration of the democratic requirements necessary to fulfil what would reflect a united curriculum. The collective constitutes valuable Euro-Western epistemologies as well as valuable indigenous and African epistemologies (Ndlovu-Gatsheni, 2015). Decolonisation needs to be located on the broader global terrain that has increasingly called for a shift towards re-centering subaltern knowledge systems and their

intellectual contributions (Kimmel, 2017). Hlatshwayo and Shawa (2020, p. 15) further argue against:

neoliberal forms of purposes of higher education, especially in teaching and learning, that are propelled by governmentality without an understanding of the South African context. Such neoliberal forms in teaching and learning tend to be posited a priori and impede the active force of *currere* that calls for newness, the creation of things unforeseen, experimentation, and the expansion of difference and movement.

Apple (2019, p. 279) posits that “we should be mindful of complexity and contradiction, of hidden relations and effects especially present within curriculum theories”. He believes that this is crucial if we are to challenge the current neoliberal, neoconservative, authoritarian populist, and managerial agendas that make it so hard to build an education worthy of its name (Apple, 2019).

The need for the decolonisation of the curriculum and understanding of teaching and learning through a decolonial lens was necessary because it resonates with the ideology embedded within *ubuntu* (Molefe, 2016), and therefore links to *Ubuntu-currere*. Le Grange (2019, p. 7) further iterates that “*Ubuntu-currere* opens up multiple courings for developing post-human sensibilities driven by the positive power of *potentia* that connects, expresses desire, and sustains life.” *Potentia* according to Le Grange (2016) is the active force and capacity that manifests in power, authority, and influence that exists within all humans. The link between SD and decolonial thinking is that *potentia* promises to counteract the manifestations of the crisis of humanism (Le Grange, 2019, p. 26). Curriculum conversations linked to decolonisation and decolonial theory require a commitment to mourning which Chilisa (2012) identifies as an important stage of the decolonisation process. Linked to this is the term *protestas* which means “to wail, protest or complain” (Le Grange, 2019). It is argued that crises (such as the lack of sustainability) are manifestations of negative power and *protestas* that produce *currere*’s reactive force (Le Grange, 2019). The decolonisation process within my study will look at including both Euro-Western and IK in science and mathematics units of work and teach these while addressing the SDGs through the curriculum. Epistemic othering becomes important for this reason and was understood through the decolonial theory within my study.

### **3.5 Coloniality and Colonialism – A Preamble towards Decolonial Theory**

Coloniality is a technical concept that denotes the interlinking of modernity with dispossession, enslavement, genocide, and epistemic violence, along with the postcolonial endurance and afterlives of these legacies (Quijano, 2000). Therefore, the link between colonialism and unsustainable colonised contexts appears to be a reality. Colonialism is the practice of acquiring political control over another country, occupying it, and exploiting it economically (Uleanya et al., 2019). The argument remains that African nations are free from political colonisation yet continue to experience colonisation in new forms via various means, such as education and economic factors amongst others (Uleanya et al., 2019). Maldonado-Torres (2011) states that while the coloniality of power referred to the interrelation among modern forms of exploitation and domination, the coloniality of knowledge had to do with the impact of colonisation on the different areas of knowledge production.

Scientific knowledge, combined with superior economic and military power, “granted the global North the imperial domination of the world in the modern era up to our very days” (de Sousa Santos, 2018, p. 28). Northern epistemologies, therefore, condition all contemporary human experience (de Sousa Santos, 2018). This conditioning of experiences is really “an intrinsically truncated experience, for it had been constructed to disregard the experience of those that were on the other side of the abyssal line—the colonial people” (de Sousa Santos, 2018, p. 34).

### **3.6 Decolonial theory**

I adopted Ndlovu-Gatsheni’s (2018) idea on decolonial theory because he troubles the importation of theory from the (global) North to interpret the data gathered in the (global) South. De Sousa Santos (2018, p. 21) believes that the end of Euro-Western epistemological hegemony and the resultant “End of the Cognitive Empire” is anchored in “the experiences of marginalized peoples who actively resist colonialism and dominant cultures of the global North”. The epistemologies of the South do not aim to replace the epistemologies of the North, but rather to overcome the hierarchical dichotomy between North and South (de Sousa Santos, 2018). It is this theoretical underpinning that guides my scholarship in this study.

Ndlovu-Gatsheni (2018) believes there is a need for careful historical and sociological research from global South contexts not informed by analytical categories borrowed from Europe and America. Decoloniality means dismantling of relations of power and conceptions of knowledge that

foment the reproduction of racial, gender, and geopolitical hierarchies that emerged or found new and more powerful forms of expression in the modern colonial world (Maldonado-Torres, 2007). The curriculum should therefore not be seen as 'innocent' nor taken for granted but seen as the site of contestation in precisely the same way as the society that gives it meaning (Kamanzi, 2016). Epistemological decolonisation is imperative if cognitive and epistemological colonialism is to be countered (Ndlovu-Gatsheni, 2018). My research which is located within an Honours module provided teachers with a platform to engage with the contestations within the science and mathematics curriculum.

Noxolo (2017) notes that the material conditions of the experience of indigenous people from which decolonial theory springs need to form the basis of how decolonial theory is understood. This theory is relevant to my study because it allows a critical exploration and a challenge to the 'colonial archive' that continues to inform global knowledge production about historically colonised others and their existential subjectivities (Hlatshwayo & Shawa, 2020).

Fanon (1952), one of the seminal scholars of decolonial theory, views decolonisation as a set of beliefs that favour's communities, indigenous life, and epistemology. These three components intersect within my study, where the community is represented by the groups of teachers and IK holders, and indigenous life focused on the use of relevant IK from literature and IK holders. Epistemology focused on knowledge production and decolonisation of units of work within the science and mathematics curriculums. Considering the correlation that exists between learning challenges arguably emanating from foreign practices in SA universities and the limited social changes experienced in the country, renders decolonisation theory relevant for exploration (Uleanya et al., 2019).

The decolonial theory is about confronting the 'epistemic violence' of a colonial, capitalist, Western-centric world system (Grosfoguel, 2012). This theory underscores the epistemicide of the 'non-Western' canon and the need for cognitive justice (de Sousa Santos, 2015). Most Eurocentric theorists, according to Allen (2016), fail to accept that the very processes of progress, modernity, development (including SD), and even emancipation (which many Western theories promote) enabled enslavement, coloniality, colonialism, imperialism, oppression, exploitation, and domination of two-thirds of the world's population. The reason I drew on the decolonial theory to frame my study as opposed to other forms of emancipatory theories like Marxism, critical theory, and critical race theories is that this study is an exploratory one. Instead of seeking to change individuals directly, the decolonial theory allows protestations through explorations and the use of

indigenous cultures and practices (Maldonado-Torres, 2011). The decolonial theory makes a more radical challenge, linked more directly to protest and confrontations with existing practice (Noxolo, 2017). Decolonisation within the SA context should draw on valuable knowledge that is present within the people within the democracy, that valuable knowledge is the IK of South Africans (Molefe, 2016). The decolonial theory stemmed from the analysis of brutal inequalities at the heart of global systems (Grosfoguel, 2012).

The call for decolonisation of the curriculum refers to books and learning content that still predominantly reflect the thoughts of Western colonial powers (van Jaarsveldt et al., 2019). Mudaly (2018a) emphasizes that for example, the science curriculum has been one of the tools used to portray Western worldviews as universal. Upon reflecting on a study conducted using science learners within the Caribbean islands, Boisselle (2016) notes that post-colonialism is about how remnants or transformed colonialist structures had affected education. In the African context, educational practices and pedagogical conceptualisations had mostly been externally influenced (Heleta, 2016). Hountondji (2009) maintains that the intellectual traditions and research in Africa were mostly externally oriented, intended to meet the academic and practical needs of the European and North American societies. The realization of education which is one of the pillars of the liberation movement means access to education that closes the gap between poor Black-African people and rich white people in SA (Heleta, 2016).

Cusicanqui (2012, p. 102) describes the “political economy” of ‘knowledge’ through which decolonial theory gets circulated in Western academic spaces in a “logocentric and nominalist version’ that fails to challenge the colonialist routes and continuing inequalities of those very spaces”. My study supports Cusicanqui’s (2012) views that decolonial theory should be driven by indigenous people, where the theory becomes a lived reality and not a romanticized fad that only contributes to scholarship and not society. My study embraces intercultural dialogue where indigenous experiences of the world have a place, together with Western thinking being included among a plurality of different knowledges (Le Grange, 2014).

### **3.6.1 Decolonial theory and indigenization**

Decolonial theorists informed an international field of ‘decolonising thought’ and shared a view of coloniality in education as a fundamental problem (Maldonado-Torres, 2011). Education within the decolonial context plays a part in reunification (Postiglione, 2017). Tuck and Yang (2012) state that decolonisation should bring about the repatriation of IK to improve societies and schools.

Decolonising recognition requires that IKS from the African continent are valued as much as those from Euro-Western contexts (Tuck & Yang, 2012).

Sium et al. (2012) aver that the decolonisation of African educational practices is always in conflict with colonial ways of reasoning and acting, however, it demands an indigenous starting point. In other words, decolonisation can only be experienced when indigenous people hold their indigenous practices in esteem and put them into action in formal and informal settings (Alfred, 2009). Corntassel (2012) posits that decolonial theory means indigenous people confronting colonial policies, institutions, structures, and beliefs, among others, to ensure the continued existence of indigenous cultures and communities. In this form of decolonisation, indigenous people are expected to neutralize colonial structures with indigenous practices (Uleanya et al., 2019). The pursuit of decolonisation in an African context through the use of IK is premised on Dani and Shah's (2016) contention that in a decolonised setting, the curriculum designed and adopted in any institution is targeted toward proffering solutions to the host community of the institution where the curriculum is to be put to use. The host community within my study was a university in SA that housed predominantly Black-African pre-service and in-service teachers serving a majority Black-African learner population. Uleanya et al. (2019) state that SD in areas where universities are situated is largely predicated on the decolonisation of the curriculum used within those universities.

Decolonization involves valuing and revitalizing IK and approaches and weeding out (apartheid) settler biases or assumptions that have impacted indigenous ways of being (Pete et al. , 2013). The decolonial theory, therefore, necessitates shifting frames of reference about the knowledge we hold; examining how we have arrived at such knowledge; and considering what we need to do to change misconceptions, prejudice, and assumptions about indigenous peoples (Pete et al., 2013). If we want to contribute to systemic change, we need to understand the concepts of indigenization and decolonisation which are terms sometimes used interchangeably, but according to indigenous scholars and activists (See Alfred, 2009; Pete, 2015), are separate yet interrelated processes. Ng'asike (2019, p. 30) posits that decolonising research refers to a "departure from traditional research methodologies based on Western ideology, drawing instead on indigenous ways of thinking and traditional beliefs about the nature of knowledge". Decolonisation methodologies underscore the preservation, restoration, and protection of local knowledge (Keane et al., 2017).

Indigenization is different from decolonisation in that, decolonising entails identifying how colonisation has impacted education and working to unsettle colonial structures, systems, and dynamics in educational contexts, whereas indigenization is efforts to reclaim, restore, and

revitalize threatened traditions (Pratt et al., 2018). Pratt et al. (2018) maintain that these two concepts are not the same, but that indigenization can inform decolonial processes.

The decolonised curriculum is based on the 4Rs central to an emergent indigenous paradigm. The 4Rs are relational accountability, respectful representation, reciprocal appropriation, and rights and regulation (Le Grange, 2016).

- Relational accountability concerns the fact that all parts of the curriculum are connected and that the curriculum is accountable to all relations (human and more-than-human).
- Respectful representation relates to how the curriculum acknowledges and creates space for the voices and knowledges of indigenous peoples.
- Reciprocal appropriation relates to ensuring that the benefits of knowledge produced and transmitted are shared by both communities and universities.
- Rights and regulation refer to observing ethical protocols that accord ownership of knowledge (where appropriate) to indigenous peoples of the world (Chilisa 2012, p. 89).

The 4Rs were important considerations in my study and framed how participants related to IK and IK holders. The units of work that teacher participants engaged with sought to be accountable (Relational accountability) not only to the Euro-Western ways of knowing but indigenous ways as well. The inclusion of IK and IK holders as resources lent itself to 'Respectful representation' within the study. Reciprocal appropriation was viewed within the context of IK being valuable to the university curriculum in the context of the Honours module but also the knowledge produced will be shared with the IK holders. Rights and regulations were observed by firstly obtaining ethical clearance from the said institution as well as getting ensuring teacher participants received consent from IK holder and did not appropriate knowledge obtained from IK holders.

Zinyeka (2016) acknowledges the epistemological differences between indigenous knowledge and school science as ways of knowing. This suggestion is based on the fact that science is concerned only with testable phenomena and all knowledge that is logically deducible from it, whereas IK embraces both testable and non-testable metaphysical phenomena (Zinyeka, 2016).

The major challenge for indigenous and scientific knowledge integration in school science is the epistemological difference between the two systems of knowing (Zinyeka, 2016). Hewson (2013)

interviewed two groups of African traditional healers to explore their IK concerning science topics and science teaching. Participants in my study also interviewed IK holders to deconstruct and reconstruct their science and Maths units of work. Hewson's (2013) study revealed that collaboration between teachers and IK holders are important to integrate IK into the school curriculum. Working with IK holders also enabled teachers to deal with the absence of epistemologies for IK (Hewson, 2013). The theme of collaboration was a major finding in my study, as will be presented in Chapter 5.

Emeagwali (2003) cited in Zinyeka (2016) notes that there are various strategies that can be used to integrate IK into the school curriculum. Emeagwali (2003) strongly advocated for instructional strategies like discussions, debates and interviews. These strategies were adopted by the groups that participated in this study. Group Five for example did make use of debates in their reconstructed unit of work. Lee et al. (2011) argued that learners become more informed when learning about IK in the context of school science. The authors further stress that an adequate understanding of learners worldviews (which may include IK) may can be used by teachers as a resource to improve learner understanding.

Smith (1999) identifies the following elements of decolonisation: deconstruction and reconstruction; self-determination and social justice; ethics, language, internationalization of indigenous experiences, history, and critique. The elements identified by Smith (1999) informed the deconstruction and reconstruction of units of work in the school curriculum by science and mathematics teachers, in collaboration with IK holders. In this study, the decolonisation process was facilitated by indigenizing parts of the science and mathematics curriculums. According to Tuck and Yang (2012) indigenizing for decolonisation is apt because IK and decolonisation are interrelated. Within this study, Smith's (1999) sentiments were addressed by analysing curriculum documents to understand the various exclusions as well as probing teachers to reveal their views about the exclusions. Exploring decolonial theory re-shapes educational practices globally, in Africa, and SA specifically (Ndlovu-Gatsheni, 2015). The use of the decolonial framework leads to an understanding of practical implementations of decolonisation (Lebeloane, 2017), one of which is the five stages of decolonisation as proposed by Chilisa (2012).

### **3.6.2 Chilisa's (2012) Five stages of decolonisation: A practical implementation of the Decolonial theory**

Ndlovu-Gatsheni (2015) believes that, for curriculum decolonisation to occur, the previously colonised are to be active in the process and not a passive audience to it. The teachers and IK holders were all of African or Indian descent (whose ancestors or personal selves were colonised). The purpose of the decolonisation process will be defeated if Europeans and Westerners became the driving force behind the decolonisation process. I borrow the five stages of the decolonisation process from Chilisa (2012) which guided the teachers in the journey to use IK (through decolonisation) to address ESD in science and mathematics education. Figure 14 represents Chilisa's (2012) five stages of the decolonisation process representing the way the process was used in my study.

Le Grange (2016) in exploring what decolonising the university curriculum might entail, drew on Chilisa's (2012) five stages of the process of decolonisation. In linking *Ubuntu-currere* with decolonisation, I also lean on the post-colonial, African scholar, Bagele Chilisa's (2012) work on decolonising research methodologies. The five stages interact iteratively in the decolonisation process, these are namely, rediscovery and recovery; mourning; dreaming; commitment; and action (Chilisa, 2012).

The various stages identified by Chilisa (2012) did not occur in isolation but in tandem with every preceding and succeeding stage, working in unison. The relationship between each stage of the decolonial turn as Maldonado-Torres (2011) puts it, is interlocking and supportive of every other stage. The teachers experienced each stage during their review of literature, engagements with IK holders, their PD within the Honours module, and their learning.

#### **3.6.2.1 Stage One: Rediscovery and Recovery**

Rediscovery is the process whereby the history, culture, language, and identity of colonised people are rediscovered and recovered (Chilisa, 2012). Recovery in the context of this study meant retrieving parts of IK that were omitted and/or removed through epistemic violence. Through decolonising the curriculum by repositioning the pedagogy and the pedagogue in higher education teachers are galvanized into "rediscovering and recovering" (Chilisa [2012] as cited in Le Grange, 2016, p. 3) culture. The importance of reclaiming IK is evident in the SA higher education curriculum (Mudaly, 2018a).

Rediscovery according to Drexler-Dreis (2018) begins by examining decoloniality as a theological praxis that recovers resources within traditions that are emancipatory rather than oppressive and imperial. Omer (2020, p. 24) posits that “the hermeneutical act of subverting totality is not only one of retrieval but also one that is historically located and re-imaginative (linked to Chilisa’s Stage 3: Dreaming), allowing multidirectional innovative exchanges.” To understand rediscovery, I draw on the symbolic indigenous Ghanaian expression of the ‘Sankofa’ which is “represented by a bird whose head is looking back while holding an egg in her beak (which is her future)” (Kwarteng, 2016). Below in Figure 13 is a representation of the Sankofa.



**Figure 13: Symbol of the Sankofa bird (Jackson-Lowman, 2014)**

The “Sankofa,” as a metaphor (for rediscovery and recovery) is expressed in the Akan language as “se wo were fi na wosan kofa a yenki.” Translated, it means “it is not taboo to go back and fetch what you forgot” (Kwarteng, 2016, p. 11). Recovery in the context of this study meant retrieving parts of the units of work (from the science and mathematics curriculum) that were removed (or omitted) through epistemic violence and redressed this by finding contextual, relevant IK that could be incorporated into the science and mathematics curriculum. Teachers retrieved both the IK and holders of the IK to do this. IK holders are forgotten and isolated members of society because they tend to hold on to what we perceive as archaic views and knowledge. De Sousa Santos (2015, p. 92) mentions that “colonialism resulted in the denigration and decimation of indigenous knowledges.”

This step was achieved by teachers researching (thereby rediscovering) indigenous approaches from the literature that they reviewed which was then used to inform revisions in new units of work. Teachers also consulted with IK holders on ways in which the units of work could practically incorporate forms of IK. Rediscovery and recovery involve colonised people exploring and

reclaiming their culture and identity (Mudaly, 2018a). Rediscovery and recovery also guided teachers in their search for IK information that was used to address the SDGs. Some of these were IK practices used by traditional people to live historically sustainable lives. A Colombian study by Sarmiento et al. (2013) revealed that some indigenous communities treated sicknesses using indigenous plants as these are more cost-effective, and can be extracted sustainably using indigenous methods. This is linked firstly to SDG 8: Decent Work and Economic Growth (UN, 2015). Some individuals from the community choose to extract these plants using indigenous methods. They sell these plants within the community, keeping both the natural resource and the monetary transaction within the community. It also links to SDG 12: Responsible Consumption (UN, 2015), whereby indigenous methods are used to extract the plants, no additives are used, and only what is necessary for use is extracted. Molefe (2016) believed that indigenous practices were often sustainable. The link to SDG 3: Good Health and Well-being (UN, 2015) is evident in the use of plants to treat diseases and help people within the community feel well. These views and approaches needed to be understood through rediscovery and recovery. Once the first stage was addressed, acknowledgment and lamenting needed to occur.

### **3.6.2.2 Stage Two: Mourning**

Mourning refers to the process of lamenting the assault on the world's previously colonised peoples' identities and realities (Le Grange, 2016). Regarding Chilisa's (2012) stages of decolonisation (cited in Le Grange, 2016), Mudaly (2018a, p. 14) relates how participants in her study "mourned the insidious ways in which a module, as part of the university curriculum, had perpetuated epistemic violence by silencing alternative knowledge systems." Maldonado-Torres (2014) encourages us to understand and accept that decolonisation is the ethical orientation of the self in conditions of systematic dehumanization. The acknowledgment of our dehumanization through the curriculum allows for mourning (Le Grange, 2016).

Mourning also referred to the process of lamenting the assault on African and indigenous peoples' epistemologies (Le Grange, 2016). Le Grange (2016) believes that mourning is an important part of purging and healing past epistemological atrocities which leads to dreaming. In my study, teachers mourned the exclusion of IKS from the science and mathematics curriculum. Teachers also lamented the fact that decolonisation and exclusionary praxis caused a lack of SD within the SA context (Kasa, 2017).

### **3.6.2.3 Stage Three: Dreaming**

Dreaming according to Mudaly (2018a) involves colonised people re-imagining an alternative curriculum that is imbued with their IK. Dreaming in this study meant re-imagining how science and mathematics units of work could be changed using intercultural pathways. It is also linked to the aspiration of addressing specific SDGs through a decolonised curriculum. Dreaming is when colonised peoples have retrieved their histories, worldviews, and indigenous knowledge systems (Stage One) to theorize and imagine alternative possibilities (Le Grange, 2016). In my study, this involved imagining a difference in units of work within the curriculum.

Omer (2020) notes that decoloniality along with emancipatory imagination points to double critique, border thinking, and interculturality as pathways for overcoming (Western) hegemonies. The Dreaming stage much like every other stage needed absolute devotion and endeavor to complete the decolonisation process and Chilisa (2012) refers to this as commitment.

### **3.6.2.4 Stage Four: Commitment**

The commitment stage began from the inception of this study. Commitment according to Chilisa (2012) refers to the process of raising one's consciousness of the muting of colonised people as it relates to the university curriculum. Commitment according to Le Grange (2016) is when academics become political activists who demonstrate the commitment to include the voices of the colonised - in this case within the science and mathematics curriculums. Hlatshwayo et al. (2022, p. 2) argue that "research on decoloniality centres a commitment to deep African pre-colonial history, the need to historicise African epistemic traditions, and specific articulations of the relationship between decolonial knowledge traditions and Africa-centredness".

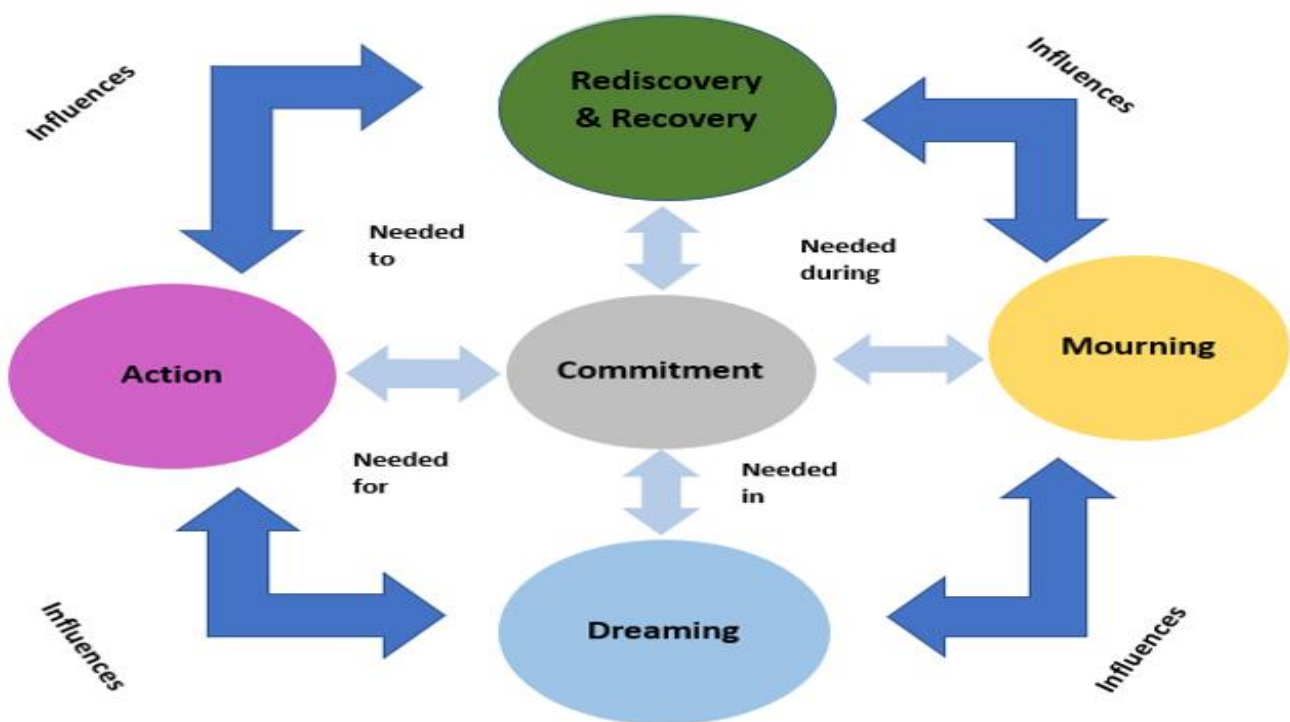
Commitment was the bedrock of the decolonisation process in this study, to which every other stage had to be committed. All the steps in this research, as will be observed in the following chapter, succeeded through a commitment to addressing the SDGs by leveraging IK. Stages One to Four would not have value if a practical enactment stage was not implemented. This is referred to as action by Chilisa (2012).

### **3.6.2.5 Stage Five: Action**

The action stage was based on deconstructing and reconstructing a unit of work from the curriculum (Mudaly, 2018a). Reconstruction is where units of work from the science and mathematics

curriculum changed to encompass now IK to address the SDGs. The action stage is embedded in the reconstruction process of this study situated within Le Grange's (2014) *Ubuntu-currere*. Action according to Le Grange (2016) is the stage where dreams and commitments translate into strategies for social transformation. In the context of this study, the social transformation was based on decolonisation and addressing the SDGs through the science and mathematics curriculum.

Figure 14 below represents Chilisa's (2012) five stages of the decolonisation process as they occurred organically during my study. The figure moreover shows that decolonisation is not a stagnant process but a continuous one (Ndlovu-Gatsheni, 2015).



**Figure 14: Five stages of the decolonisation process adapted from Chilisa (2012)**

Figure 14 is adapted from Chilisa (2012) and presented as an interactive model to emphasise the iterative nature of the decolonisation process in our study. Each stage of the decolonisation process is not linear as within product-driven Euro-Western curriculum approaches. There is iteration and connectedness among the five stages of the process. Rediscovery and recovery of excluded IK can give rise to mourning (regret and sadness) when the marginalization of valuable indigenous ideologies relevant to units of work is acknowledged. This mourning can, in turn, give rise to dreaming (curriculum imaginations and re-imaginings about a culturally inclusive curriculum) (Ogunniyi, 2023). However, while historically marginalized IK are reflected on with a view to

including low voices, and the realisation of the enormity of the consequences of the historical silencing of IK can trigger renewed mourning. Dreaming also has the potential to stimulate commitment to act, to rediscover, to dream further, and to mourn further.

The decolonial theory was relevant to this study which sought to achieve levels of social justice by addressing the SDGs (Especially SDGs 4 and 10). De Sousa Santos (2015) highlights that the struggle for global social justice is inseparable from the struggle for cognitive justice, which is informed by decolonial theory. The decolonial theory works to decenter and interrupt Eurocentric knowledge and colonial hierarchies that have been constructed over years and attempt to delink from the oppressive logic of Western modernity (Quijano, 2000). Involving IK holders to contribute to the teaching of science and mathematics, created opportunities for teachers to deconstruct and reconstruct units of work in the curriculum.

### **3.7 Conclusion**

This theoretical framework chapter focused on discussing the world-views that informed my study. I began by highlighting the importance of drawing the link between curriculum studies and how it relates to curriculum theories, one of which was used to inform the outlook of my study. I detailed a reconceptualised curriculum by drawing comparisons to the notion of *currere* and the curriculum as an Autobiographical method. To localize how I adopted the curriculum theory I went on to discuss *Ubuntu-currere* as proposed by Le Grange (2014, 2019, 2021) and adopted decolonial ideologies as explained by Hlatshwayo et al. (2020). I then highlighted conceptions of the decolonial theory and narrowed it down to focus on decolonial theory and indigenization which was specific to this research and is based on leveraging IK. I furthermore discussed the practical implementation of the decolonial theory by describing Chilisa's (2012) five stages of decolonisation as they occurred within my study. These theories informed the various steps and stages within this study and influenced the research design which will be presented in the next chapter.

## **Chapter Four**

### **Research Methodology**

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## **4.1 Introduction**

This chapter will discuss four broad sections, namely theorizing the methodological approach used, the data generation methods and techniques adopted, the analysis process, and issues of trustworthiness and ethics. The call for decolonisation in education recast the gaze of scholars (like myself) towards methodologies and ideologies emanating from global South contexts. I first discuss the context of this study and describe the approach and paradigm used. My use of purposive sampling will then be advocated for. This qualitative study was located within the critical paradigm and a democratic participatory study design was adopted; these will be discussed. The data generation methods, which included FGIs, document analysis, teachers' micro-teaching observations, reflections generated by teachers, and field notes (FN) are elaborated on and discussed. I then justify the use of the respective research instruments that advance the trustworthiness of the data. I conclude this chapter by specifically discussing the trustworthiness of the study, ethical issues, and limitations of this research.

Teacher groups comprised two or three practicing science and/or mathematics teachers and one IK holder, the latter who could have been an 'Isangoma', an 'Inyanga', an elder who served as a resource person, or any other knowledgeable individual, offering information and insight into using IK to decolonise the science or mathematics curriculum. Firstly, groups of teachers selected a unit (of work) from the CAPS curriculum and 'deconstructed' it to find opportunities to incorporate IK and address ESD. Secondly, participants 'reconstructed' units of work by incorporating IK (with the help of IK holders), and then, addressed SDGs which were relevant to their particular context.

## **4.2 Context of the study**

Agenda 2063 emphasizes the importance of education as a regional response in Africa to achieve the SDGs (AU, 2015). The Honours module drawn on in this study encompassed the decolonisation of the science and mathematics curriculums using IK. The module also expressed a focus on teacher PD (outlined in Appendix D) and education for societal relevance within the content covered and the broader aims of the module. The aspect of the SDGs through ESD is directly linked to societal relevance. Knowledge of the aims and the outcomes of the Honours module were communicated to me by the lecturers who had taught this module.

Teachers studying the Honours module were asked to arrange themselves into groups. Teachers taught science or mathematics and invited an IK holder to assist them in their work.

I (the researcher) was not a part of a group. I served as a co-learner with teachers, and a source of guidance and information on the structure of the project since I understood the project and requirements from engaging with the lecturers teaching the module in question. I aligned my project with selected topics in the Honours module.

### **4.3 Critical Paradigm**

I draw on the critical paradigm as a social scientific paradigm which according to Rubin and Babbie (2017) which is based on power, inequality, and social change. Social science can never be truly value-free and should be conducted with the express goal of social change in mind (Rubin & Babbie, 2017). In the context of my study (global South), reference to the critical paradigm is leveraging a distinct set of beliefs which informed my work.

The critical paradigm is premised on the belief that research is conducted for “the emancipation of individuals and groups in an egalitarian society” (Cohen et al., 2017, p. 26). This paradigm oriented my study. The critical paradigm is an amalgamated form of research dispensation which seeks to give a voice to the oppressed members of society (Cohen et al., 2017). The critical paradigm resonated with the decolonial theory I adopted. This paradigm embodies different ideologies such as postmodernism, neo-Marxism, and feminism (Pham, 2018). Theories related to decolonisation fall within this ideological realm. According to Creswell (2014, 57), “research should contain an action agenda for reform that may change the lives of participants”. From this aspect, the “critical paradigm has been used to develop connections among the economic, political, social, and cultural standards of contemporary societies” (Pham, 2018, p. 23). In my study, those connections were related to curriculum decolonisation, teacher PD, and the SDGs. We live in a world where teachers’ roles are restricted to their schools or their classrooms (Pham, 2018), and they cannot participate in decision-making processes (Cohen et al., 2017). My study was located within this paradigm in a way that allowed teachers to address the SDGs within their professional practices.

The freeing of the teachers’ ideas and development of teacher agency through leveraging IK and addressing SD was one of the intentions of this study. The teachers freed themselves from the shackles which confined their teaching to a single (Euro-Western) episteme and ventured into teaching and learning science and mathematics through epistemologies informed by alternative knowledge such as IK. Co-learners (including myself, the researcher) were able to explore and understand the nature of secondary colonisation that occurs through the curriculum which is based

on a single episteme. The troubling of the normalised identity of who a knowledge holder in science and mathematics is, and what knowledge should be perpetuated as valuable knowledge, occurred. This led to the freeing of the mind, the nature of which is described in the data analysis chapter of this study. Maldonado-Torres (2011) believes that the decolonisation of the mind may lead to a move away from the coloniality of the mind. The understanding from observing teachers' (micro-teaching) presentations led to a process of learning about decolonisation and the role of IK, especially within ESD.

This paradigm was suitable for my study because it allowed for heightened awareness of the Euro-Western ideology that underpins the curriculum. In my study, the IK holders whose ideologies have been silenced and oppressed by powerful authorities for centuries were able to collaborate with teachers to contribute towards decolonising units of work. The critical paradigm, according to Asghar (2013, p. 3123), "is more philosophical, and hence more accommodating by nature as compared to other paradigms that are more methodological and less concerned with the independent nature of truth or reality of life". Kincheloe (2008) states that in education, the teacher community can imbue their practices in the classroom and improve the qualities of education for their learners by engaging in competent, critical research. Critical research was undertaken by many of the teachers as part of their journey towards decolonising the curriculum.

The willingness of the teachers to transform units of work by adopting a decolonial lens and using IK to address the SDGs articulated well within the critical paradigm. Cohen et al. (2017) mention that the critical paradigm focuses on change, empowerment, transformation, and emancipation. The focus on decolonising the curriculum resulted in a change in the units of work based on teachers' intellectual courage and emancipation. Providing opportunities for participants to become more aware of the SDGs and not to be limited by dictates of the curriculum and textbooks, led to a form of empowerment and a transformation in their views.

Cohen et al. (2017) further argue that the main aim of critical research is to transform and change individuals. The focus was not only on changing the content of units of work but also on the pedagogical practices of teachers to accommodate the SDGs within the curriculum by leveraging IK. Teachers teaching differently would result in learners having to learn differently. The incorporation of IK into units of work in the curriculum was a dynamic approach to influencing policy from a decolonial standpoint. The Honours module which focused on SD through a decolonial lens already impacted the curriculum policy at the HEI where this study occurred, as part of the "transformation agenda" (Knudsen & Andersen, 2019).

#### **4.4 Qualitative Research Approach**

The qualitative approach underpinned this study. Qualitative research according to Creswell (2014) involves individuals developing subjective meanings of their experiences. Creswell, (2014, p. 37) further states that in qualitative methodology “meanings are varied and multiple, leading the researcher to look for the complexity of views”. The goal of my research was to rely on the teachers’ conceptions of the situation being studied. In my study, participants developed many of their views on colonisation and ESD from their engagements with activities in the Honours module. The qualitative approach was apposite because it dealt with individuals and their experiences with units of work in the sciences and mathematics curriculums; these cannot merely be put into numerical categorizations but are, instead, experienced and understood (Creswell, 2014).

Creswell and Creswell (2017) highlight the following characteristics of qualitative research which were used to guide my study: It occurs in a natural setting, the researcher collects data from that setting, and there is descriptive data generation as opposed to numerical. Qualitative research is also focused on the reasoning of phenomena and not merely the outcomes (Mertler & Charles, 2010). Things occur the way they do during the research and the thinking of participants and motivation for that thinking is emphasized (Mertler & Charles, 2010). Qualitative researchers according to Corbin and Strauss (2014) aim to explore the experiences of participants and how their meanings are formed. Teachers' review of units of work informed by their views was personal and specific to the Honours module and this study. Creswell (2014) describes qualitative research as the procedure for the interpretation of a person or group’s views of a societal or human issue. My research addressed specific views on TPD and units of work based on the issues of decolonisation, IK, and the SDGs.

Creswell and Creswell (2017, p. 120) identify “qualitative research as an “emerging process” where the investigator does not enforce his or her opinions but seeks to understand the participants’ insights and views”. In addition to documenting the experiences of the participants, the processes and reflections that teachers engaged in were described. Each group contributed detailed reflections from engagements with IK holders who contributed to their projects.

#### **4.5 Participatory Research Design**

Hall and Tandon (2017) note that participatory research is about knowledge as an action strategy for change and about rendering visible excluded knowledges of our planet. The change in units of

work to reveal IK and SD knowledge through the process of “action” (Chilisa, 2012) was observed in my study. Hall and Tandon (2017, p. 9) are particularly concerned with “reinvigorating the practices of participatory research that originated in the global South some 40 to 50 years ago, but has been forgotten as the location of theory development in community-based or engaged research seems to have shifted to the global North.” The element that makes this study “participatory”, according to Creswell and Creswell (2017) is the substantial involvement of teachers and community personnel (IK holders) in many aspects of the study.

This study adopted a participatory design and this was suitable because, according to Creswell and Creswell (2017), a participatory study requires substantial involvement of teachers and community personnel (these include IK holders). I adopted a participatory design to explore how teachers leverage IK to address sustainable development. The qualitative participatory research design which was framed by critical paradigm taken is ideal for the study. The design used is particularly important for the decolonization interests of the study, which should seek to conduct research with people, rather than on people. The study involved actual teachers in an assignment that culminated in micro-teaching sessions. I positioned the participatory design within the context of qualitative research, paradigmatically positioned within the critical paradigm.

The design which informed the design of this study is a direct consequence of adopting the ideology of *ubuntu* and the *Ubuntu-currere* theoretical framework. This approach resulted in the design and theory of study being informed by literature and scholarship from eminent scholars in the global South. De Sousa Santos (2018, p. 22) argues that the “End of the cognitive empire is replete in the concept of the epistemologies of the South” where he outlines a theoretical, methodological, and pedagogical framework for challenging the dominance of Eurocentric thought.

Alenaizi (2018) defines participatory research as an alternative style of research using a three-part process of social investigation, education, and action to share the creation of social knowledge with oppressed people. The social investigation into how SD can be addressed through the study of an Honours module which will directly impact basic education through the action of collaborative professional development was informed by Alenaizi’s (2018) understanding of participatory research. Participatory research has the explicit intention of collectively investigating reality to transform it (Alenaizi, 2018). In the context of my study, teachers studying the Honours module served as co-researchers and worked collaboratively to pool their collective insights. This is in keeping with the notion of ‘*ubuntu*’ (addressed earlier) and a democratic participatory design.

Hall and Tandon (2017) note it is often forgotten that participatory research emerged initially from the indigenous communities who engaged in research. The participatory research design according to Leavy (2017) seeks to democratize research design by studying issues with the full engagement of those affected by it. This involves working collaboratively to develop a research agenda, collect data, and design actions to affect social change (Leavy, 2017). In the context of this research study, teachers, IK holders, and I engaged with the curriculum by gazing through a decolonial lens and addressing the SDGs in science and mathematics education. The collaborative nature of this study required that teachers engage not only with one another and the curriculum, but also with IK holders, their lecturers, and I, through PD (Appendix D) within the Honours module. Participants redesigned units of work from the science or mathematics curriculums while simultaneously addressing the SDGs, which was based on an imperative to work towards social change. Democratic ideals include tenets from debates about decoloniality, which are aimed at neutralizing power and dominance. In my study, the power and dominance of invisibilised ideologies which underpin the curriculum were critiqued.

The PD of teachers was an important intervention in this study. A summary of this is presented in Appendix D and is to be read in conjunction with this chapter. In pursuance of an inclusive perspective, teachers collaborated with IK holders to unearth IK that could link to units of work from the science and mathematics curriculum. Zinyeka et al. (2016, p. 257) call these “intersecting domains of overlapping strands”. However, unlike the teachers in the study by Zinyeka et al. (2016), the teachers in my study began by understanding the processes, products, and significance of cultural practices which constituted TPD. One of the PD activities occurred when teachers and IK holders met to discuss and revise units of work from the curriculum. I was invited to attend teacher group meetings which were held with IK holders and served only as an observer (Appendix D). Some highlights of these are reported as field notes. The group discussions and reconstruction of units of work to address the SDGs through leveraging IK were focused on four subject areas that exist within the study of the science and mathematics Honours module, namely, Physical Sciences, Life Sciences, Natural Sciences, and Mathematics.

Cumbo and Selwyn (2022, p. 2) explain that “participatory design can be defined as an approach to support mutual learning through equitable partnerships of communities and experts through the design of an intervention.” The intervention in my study was a part of the PD in which teachers engaged during their study of the Honours module. Educational researchers adopt the participatory design to produce learning artifacts, tools, and spaces that reflect the needs and experiences of

students (Cumbo & Selwyn, 2022). Govender and Mudzamiri (2022) more especially herald the use of indigenous artefacts for learning. Lesson plans, resources, and collaborative spaces were produced as a consequence of TPD within this study, the nature of which will be presented as data. This design was apt for my study because I sought to remove traditional power disparities. Cumbo and Selwyn (2022) further note that a democratic participatory design supports the participation of teachers in the design of educational interventions from which they were previously excluded. Cumbo and Selwyn (2022) believe that the removal of power disparities between the 'expert' designer (or researcher) and all other participants allows everyone involved the opportunity to share their expertise and influence in all stages of the research.

#### **4.6 Sampling Strategy**

Purposive sampling was used to recruit teacher participants. Creswell (2014) mentions that in purposive sampling, specific characteristics of the population which would enhance understanding of the phenomenon are sought. Approximately 36 post-graduate teachers were purposively selected to participate. Two to three teachers formed a group. Six groups of science teachers and six groups of mathematics teachers were formed. This comprised 12 teacher groups from the class of 36 studying the Honours module.

The purposive sampling strategy, also called judgment sampling, is a deliberate choice of a participant due to the qualities the participant possesses (Etikan et al., 2016). Teachers in my study were selected based on the following criteria: They were all studying the science and mathematics Honours module at a SA university and volunteered to participate in the study. Creswell (2012) maintains that researchers use their discretion to choose participants and places for the research to explore the central issue of the study. The reason for selecting this group of teachers was that they had engaged in discourses about decolonising the curriculum as part of their work in the Honours module. The first 12 teachers (six for FGI1 and six for FGI2) who volunteered to be a part of the FGIs were interviewed. Portfolios of evidence (PoEs) including reflections and group presentations (micro-teaching) by teachers who volunteered to be a part of the FGIs were presented in the data. There were 12 PoEs from the 12 groups which were submitted and analysed in total.

Table 3 details the biographical description of the participants who engaged in the FGIs, developed PoEs, and presented micro-teaching lessons. All 36 teachers who were science and mathematics teachers completed group PoEs which included individual reflections. Twelve teachers took part in

the FGIs (six teachers for FGI1 and six teachers for FGI2). Both focus groups were selected based on those who were first to volunteer and in (FGI2) whose units of work showed detailed practical strategies to address the same or similar SDGs using IK for a more in-depth discussion (especially for FGI2).

**Table 3**

***Biographical information of teachers who engaged in FGIs***

<b>Teacher participant (pseudonym) and teacher group number</b>	<b>Subject selected for task</b>	<b>Selected Grade and unit of work</b>	<b>Focus group Interview (FGI) one 1 or 2 engagement</b>	<b>Gender Affiliation</b>	<b>Race</b>
1. Presh (Group Four)	Mathematics	Grade 6: Functions, and Algebra	FGI1	Female	Black-African
2. Nicki (Group Nine)	Physical Sciences	Grade 10: Hydrosphere	FGI1	Female	Black-African
3. Samuel (Group Ten)	Physical Sciences	Grade 10: Acids and Bases	FGI1	Male	Black-African
4. Lee (Group One)	Life Sciences	Grade 11: Cellular respiration	FGI1	Male	Black-African
5. Thobisa (Group Seven)	Mathematics	Grade 4: Geometric patterns	FGI1	Male	Black-African
6. Gift (Group One)	Life Sciences	Grade 11: Cellular respiration	FGI1	Male	Black-African
7. Essy (Group Five)	Natural Sciences	Grade 6: Inorganic Fertilizers	FGI2	Female	Black-African
8. Will (Group Two)	Mathematics	Grade 6: Patterns, Functions, and Algebra	FGI2	Male	Black-African
9. Sbu (Group Five)	Natural Sciences	Grade 6: Inorganic fertilizers	FGI2	Male	Black-African

10. Precious (Group Two)	Mathematics	Grade 6: Patterns, Functions, and Algebra	FGI2	Female	Black- Indian
11. Cat (Group Eight)	Physical Sciences	Grade 10: Hydrosphere	FGI2	Female	Black- Indian
12. Dwayne (Group Eight)	Physical Sciences	Grade 10: Hydrosphere	FGI2	Male	Black- Indian

The table above shows the pseudonyms of the teachers in this study, the teachers' group numbers, the subject they taught, their race and gender classification, and the unit of work they selected to leverage IK and address the SDGs. It also shows the FGIs in which each teacher took part. The pseudonyms that teachers selected were a mix of names from both African and Euro-Western origins (i.e., Sbu and Samuel), this reflected which nicknames were popular amongst teachers (similar to valuing a plurality of knowledge which I subscribed to in my study).

It was important to record the gender of the teachers because SD-related issues are not gender-neutral. Gender features in "SDG 5: Gender Equality" and in many other SDGs. The validity of including race as a biographical criterion in Table 3 above is linked to indigenous culture and the notion of decolonisation which is central to my study. The vestiges of oppression of non-whites have permeated the post-apartheid SA education system (Christie, 2020). The teachers were made up of a population of historically disenfranchised groups like the Black-African and Black-Indians of South African who worked toward decolonising the curriculum. The racial and gender permutations expressed in Table 3 influenced how teachers addressed Chilisa's (2012) "mourning" and "re-discovery and recovery" stages which were discussed in Chapter Two. These racial affiliations were important considerations specifically to understand the way teachers leveraged IK to address the SDGs.

Creswell (2014, p. 63) notes the importance of "availability and willingness to participate, and the ability to communicate experiences and opinions in an articulate, expressive, and reflective manner." Teachers for the FGIs were selected based on their interest and willingness to engage in these interviews. The first six teachers who volunteered were used for the first FGIs. After the presentations, I chose the next six teachers who volunteered to take part in the second FGIs.

After selecting their unit of work, teachers invited IK holders to contribute their knowledge to the teachers' work. This was during the first two weeks of studying the Honours module. Each IK holder also selected a pseudonym by which they wanted to be referred. The IK holders were not interviewed but their valuable contributions to this study were captured by teachers as entries in reflective diaries and during FGI2 and micro-teaching presentations. The IK holders were participants recruited by teachers in this study. Teachers were given agency to select IK holders with the knowledge and experience in IK relevant to the unit of work teachers selected. Selecting IK holders for teachers would not have been ideal. Teachers referred to the IK holders using their pseudonyms. I present the pseudonyms of the IK holders who were linked to teacher groups whose PoEs and micro-teaching observations were included in my analysis of the data.

Teacher Group Eight worked with a male IK holder who selected the isiZulu pseudonym “Nkunzi” which translates to “Bull” in English. Nkunzi is a community elder and a respected source of wisdom and knowledge on indigenous technologies in his community. Group One worked with a female IK holder who selected the pseudonym “Imbokodo”. “Imbokodo” is the isiZulu word for “a rock”, which Africans use to denote a strong, resilient identity. Imbokodo was an African, “Isangoma” (diviner) who was the designated ceremonial Umqombothi (African traditional beer) producer in the community. Group five’s IK holder was Amandla. “Amandla” is the isiZulu word for “power”. Amandla was a local female farmer and a valued elder who was known by the community to be a repository of indigenous knowledge. Group Two selected an IK holder who was a Black-African, male, jewellery artisan who chose to be called “Umdwebi” which is the loosely translated isiZulu word for “Craftsman”. He was a valuable member of his community and revealed a wealth of knowledge on African art and beadwork.

## **4.7 Steps in the research**

### **4.7.1 Step A: Pilot study**

Eldridge et al. (2016) note that pilot studies focus on development before a future wider development project takes place. The function of pilot studies is to check research instruments and methodology, but also to reveal ethical and practical issues that may hamper the main study (Doody & Doody, 2015). I adopted Doody and Doody’s (2015) explanation of a pilot study which enhanced the validity of the data I collected. Pilot studies, according to Majid et al. (2017) are small-scale studies and can be useful in the process of conducting interviews as they highlight opportunities

and possible challenges that may arise in the major study. One of the ways data was collected from teachers was by conducting focus group interviews (FGIs).

I conducted a pilot study with two groups of practicing teachers (three teachers per group who also invited IK holders). They made up one mathematics teacher group and one science teacher group. The six teachers in the pilot study were not from the Honours cohort, and therefore were not part of the final sample of teachers. The teachers in the pilot study were however invited to view the lecture presentations, had access to the Power-point presentations used to teach the module, and were given copies of the tasks that required them to decolonise units of work from the science or mathematics curriculum by leveraging IK to address the SDGs.

Based on the pilot study I realized that interview questions had to be edited to address the phenomenon of the study more effectively. For example, in Appendix B1, FGI1, Question nine read, “How can sustainable development be addressed through decolonising the curriculum? Explain.” This question was assumptive and was removed and replaced with a different question: “Do you think sustainable development can be addressed through decolonising the curriculum? Explain.”

Another question in Appendix B1, FGI2, also seemed assumptive, according to a teacher who participated in the pilot study. Question 21 read “Why would you recommend leveraging indigenous knowledge to address Sustainable Development Goals within other subjects? If so, which subjects?”. This question was removed and replaced with the question, “Would you recommend leveraging indigenous knowledge to address Sustainable Development Goals within other subjects? If so, in which subjects?”. I had to change details on all the interview and observation schedules because teachers in the pilot study were not comfortable with being called ‘students’. They wanted to be called teachers or teacher participants. I analysed the PoEs, read the reflections, and observed their presentations. The relevant changes were affected in all the instruments used in the main study according to the learning experienced during the pilot study.

#### **4.7.2 Step B: First Focus Group Interview**

The first research question was “How do science and mathematics teachers address sustainable development by leveraging indigenous knowledge?”. To answer this research question, I conducted the first Focus group interviews (FGI1) using the FGI Schedule (Appendix B1). Appendix B1 comprises different questions for FGI1 and FGI2. These two sets of FGI questions were different

questions Teachers responded to the first FGI questions which were based on their understanding of how they leveraged IK and addressed the SDGs, before their engagement in the PD programme.

#### **4.7.3 Step C: Deconstruction and reconstruction of units of work through teacher-driven research and engagement with IK holders**

Step C focused largely on the deconstruction and reconstruction processes. The groups deconstructed a unit of work and thereafter reconstructed it using IK while addressing the SDGs. The processes in Step C were linked to the stages of decolonisation as identified by Chilisa (2012) presented in Figure 14 of Chapter Three. The focus was mainly on the “Commitment”, “Dreaming” and “Action” stages of the decolonisation process as teachers planned to use IK to address the SDGs.

To leverage IK to address the SDGs, teachers studied materials from different sources, including published works, and collaborated with IK holders (who served as co-teachers and resource people). These activities allowed teachers to decide about IK which could be infused into units of work to address the SDGs. The groups engaged in various discussions with IK holders to obtain knowledge about content and methods related to the teaching of their unit of work. These were captured within their reflective diaries, micro-teaching presentations, and through the responses of participants who took part in FGI2. This process was followed by re-designing the unit of work they selected from the CAPS, in terms of content, pedagogy, learning activities, and context of learning.

I maintained a field diary to document my knowledge development, events, and methodological decisions in the research field which are reported as field notes (FN). Reflections and observations (in the form of FN) informed this step and my reporting. Teachers reflected during these processes and submitted these with their PoEs.

#### **4.7.4 Step D: Teachers' micro-teaching lesson presentations**

Teachers presented selected ideas about content and pedagogy related to achieving SDGs by including IK, which had been detailed in PoEs, during micro-teaching sessions. They also presented excerpts from their engagements with the IK holders. Micro-teaching was an organic professional development process, whereby teachers explained their critique of the unit of work they selected using critical analysis (deconstruction) and then presented the reconstruction of the unit of work. Micro-teaching sessions were subjected to observation. Observations of micro-

teaching sessions enabled a deeper understanding of teachers' behaviours and strategies related to *doing* decolonisation by leveraging IK to address the SDGs. I reflected on these engagements using my field notes. The observation of micro-teaching sessions was done using an observation schedule (OS) (Appendix A1).

Step D mainly contributed to answering research question 2 which is: What are the pedagogical experiences of science and mathematics teachers who have engaged in professional development activities in planning to enact the school curriculum by leveraging indigenous knowledge (a) What types of strategies do science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address sustainable development goals? The second FGI (FGI2) contributed to my understanding of the second part of research question two which states, (b) Why do science and mathematics teachers who have engaged in professional development activities use the strategies they use? The Honours module included a professional development exercise to equip the teachers with the necessary skills to decolonise the curriculum and address the sustainable development goals in their classrooms. The completion of the task and their presentations (micro-teaching) and responses to the FGI2 questions were based on their aspirations and planning towards decolonising and the curriculum.

#### **4.7.5 Step E: Document Analysis (Portfolios containing lesson plans and other support materials)**

This step was key in also answering the second research question. The difference is that the analysis of the teachers' documents provided deeper insight into practical strategies that they adopted to work towards decolonising the selected unit of work. I examined teachers' PoEs as well as my observation transcripts based on their (micro-teaching) presentations. I analysed the PoEs used by the different groups to inform their lessons which they used in their micro-teaching presentations. I analysed their lesson plans, the Power-point presentations they created, their resources, and support material which all formed a part of their PoEs. Teachers also submitted their reflective diaries in the PoEs for analysis.

#### **4.7.6 Step F: Second Focus Group Interview**

Teachers were interviewed within the focus groups to elicit their views on the units of work they presented during micro-teaching sessions. Participants who took part in the FGI1 were different

from those who participated in FGI2. Teachers who had volunteered for FGI1 did not volunteer to participate in FGI2. Therefore, the second set of six teacher volunteers was selected to participate in FGI2. This study accommodated the availability of participants to make the project doable.

Step F was based on understanding the factors that may have obstructed or enabled teachers while they were trying to leverage IK to address the SDGs (Objective 3). The second FGI also focused on how teachers responded to the challenges of leveraging IK and addressing SDGs in the school curriculum. This elicited more information related to the second research question, as well as the third research question which was “What are the experiences which enable or constrain teachers who seek to address sustainable development goals by leveraging indigenous knowledge? (a) What factors are obstructive or enabling when leveraging indigenous knowledge to address Sustainable Development Goals in the school curriculum? (b) How do science and mathematics teachers respond to these factors?

Questions on the types of strategies that science and mathematics teachers used when leveraging IK to address SDG in the school curriculum and why they use these strategies were also asked in FGI2. This also allowed for the generation of data related to the third research question as teachers spoke about what was enabling and obstructive during their activities. The second FGI also served to understand what opportunities were leveraged by teachers to decolonise a unit of work using IK to address SDGs in the curriculum.

## **4.8 Data Generation**

The generation of data in this study involved various methods and instruments. Qualitative data came from many sources like interviews, observations, and PoEs which included reflective diaries, and field notes.

### **4.8.1 Data generation methods: A brief synopsis**

This study used five data generation methods.

- Data Set One: Focus group interviews with teachers before and after their engagement in the Honours module were done using interview schedules (Appendix B1).

- Data Set Two: Observations were done of teacher group micro-teaching presentations which were based on their decolonisation of a unit of work using an observation schedule (Appendix A1).
- Data Set Three: Document analysis to analyse PoEs (which included CAPS and supporting documents, lesson plans, and textbook extracts) that were used to decolonise a unit of work in either the science or mathematics curriculums using IK to address the SDGs (Appendix C).
- Data Set Four: Teachers reflected throughout this study and documented their written reflections in reflective journals (Appendix E) which were analysed.
- Data Set Five: I kept a researcher journal that documented my knowledge development as well as that of the teachers. These were used to record research activities in the form of field notes throughout my study.

Table 4 below documents a summary of the data generation process along with the participants, their actions, strategies, and instruments used.

**Table 4**

***Summary of data generation section***

<b>Participants</b>	<b>Action of Participant/s</b>	<b>Data Generation strategy</b>	<b>Instrument</b>
1. Teachers	Respond to the first FGI questions based on their understanding related to leveraging IK and addressing the SDGs before PD activities.	Focus group interviews	FGI Schedule  (Appendix B1-FGI1)
2. Teachers	Present Lesson plans	Observations of micro-teaching	Observation Schedule (A)
3. Teachers	Submit a portfolio of evidence with Reflective diaries.	Document analysis	Document analysis template (Appendix C) and Reflections (Appendix E)
4. Teachers	Respond to the second FGI questions about how they leveraged IK to address the SDGs after engaging in PD activities	Focus group interviews	FGI Schedule  (Appendix B1- FGI2)
5. Researcher	Recorded notes in the form of learning during the entire research process.	Field/research Notes	Researcher journal/notes (informal)

#### **4.8.2 Research Methods and Instruments: A detailed account**

An initial immersion phase took place where I, the researcher, and co-researchers (who were the teachers studying the Honours module) spent some time focusing on lectures that engaged with the concepts of decolonisation in education and ESD. Payne and Barbera (2013) believe that immersion is important to understand a research context. The immersion process needed to take place first in order to understand the approaches and methodologies that would be most appropriate to the context of the study and the participants (Payne & Barbera, 2013). More than this, the immersion phase was an in-depth discussion and enactment of decolonising units of work by teacher groups. Teachers formed groups of two/three and connected (physically and via email/telephonically) and planned for the units of work they wished to use to address the SDGs in an ESD model. The decision to choose an IK holder who formed part of their teacher groups was based on the units of work specific teacher groups chose. Teachers were encouraged to observe COVID-19 regulations and connect with the IK holder virtually or if they met physically, social distancing needed to be observed.

Interview schedules for the FGIs (Appendix B1) were used and transcripts were presented in Appendix B2. Templates for observations of micro-teaching presentations (Appendix A1) and document analysis (Appendix C) were also used. Interviews with the focus groups were semi-structured which according to Abawi (2013), includes several planned questions, but the interviewer has more freedom to allow unplanned conversation, together with in-depth interviews become less structured, and the wording and questions are not all predetermined. The semi-structured interview allowed for dialogical engagement between participants during the FGIs.

Observation notes (which I recorded on the OS) according to Trigueros et al. (2017) can account for participants' behaviour, environment, and physical movements or symbols related to the phenomenon being explored. The use of the document analysis using a template provided insight into teachers' efforts to integrate IK to address SDGs, using a decolonial lens, which became evident by examining materials used in PoEs. Bowen (2017) endorses the use of document templates because it creates a systematic procedure for reviewing or evaluating documents to elicit meaning, gain understanding, and develop empirical knowledge. This was important since teachers engaged in a module within a global South content. The view of self as an educational practitioner was vital. All five data generation sets offered a unique perspective on the phenomenon being studied.

#### **4.8.2.1 Document Analysis: PoEs (which included CAPS, Lesson Plans, Textbook Extracts, Reflections, and Learning and Teaching Support Materials [LTSM] and Power-point slides)**

Gibbs (2018) mentions that document analysis involves the study of documents to understand substantive content or to express deep meaning. Document analysis of the CAPS curriculum documents, prescribed textbooks used by teachers, textbook extracts from the unit of work they chose, science and mathematics support material as well as reference material they used, was conducted by teachers using Critical Discourse Analysis (CDA) (see Appendix D). They included this analysis in their PoEs.

I subsequently conducted an analysis of teachers' PoEs including the extracts they included which highlighted their own analysis. Yin (2018) states that documents supplement the information obtained from other sources. This type of document analysis was done to understand if and where colonial ideologies were covertly perpetuated, track the decolonial process, and observe ESD in action. Teachers also conducted their analysis of the CAPS curriculum and other resources which they put into their PoEs, which I then analysed. Portfolios of evidence have been widely used to track evidence of their learning, reflect on their evaluation, and promote self-directed learning (Song, 2021). By analysing PoEs an understanding of teachers' agency and self-directed learning was achieved. Teachers included textbook extracts, teaching and learning support materials, lesson plans, CAPS documents, and their analysis of the aforementioned documents. These were analysed as a part of the PoE analysis (as per the document analysis schedule [see Appendix C]).

#### **4.8.2.2 Observations**

Cohen et al. (2017) concur with Steber (2017) by noting that observations are processes that offer investigators live data from naturally occurring social situations. Teachers' micro-teaching presentations were a social practice that was observed and are described in section 4.7.4, Step D. Remesh (2013, p. 12) states that "micro-teaching is a teacher training technique which provides teachers an opportunity to develop their teaching skills within a practice context before implementation within a formal classroom". Micro-teaching is used to rehearse teaching strategies and has been effective in developing science teaching skills (Ralph, 2014). Observations of this accounted for participants' behaviour, physical movements, and symbols related to the

phenomenon being explored (which was exploring how teachers leveraged IK to address the SDGs).

The process was guided by the observation schedule (Appendix A1). The units of work selected and micro-teaching approaches selected were left to the discretion of each teacher group. This further highlighted agency and the self-learning process teachers had developed. A well-researched micro-teaching presentation that reflected decolonisation and addressed the SDGs through the selected unit of work was the focus.

#### **4.8.2.3 Focus Group Interviews**

Focus group interviews were important in my study because they allowed teachers to voice their views about the issues of a colonised and a decolonised curriculum as well as SD. These are phenomena that teachers seldom consider (Tikly, 2019). The use of FGIs was also relevant especially since many of the PD exercises (outlined in Appendix D) within the Honours module were conducted in groups. The selection of FGIs as a data generation method was consistent with the adoption of the democratic participatory research design of my study. Teachers engaged collectively in their PD process and it made sense to adopt a data generation method that was consistent with the collaborative nature of my study. Focus group interviews were a useful qualitative method to “encourage discussion among participants on the topic of interest” (Schutt, 2018, p. 9). Sim and Waterfield (2019) locate focus group interviews somewhere between a meeting and a conversation where individuals pick up on one another’s contributions, which is consistent with the collaborative dynamics of this study. I conducted FGIs with 12 teachers. I audio-recorded and transcribed both FGIs.

#### **4.8.2.4 Reflections**

Reflections (Appendix E) by teachers were recorded throughout their engagement within the Honours module. The decolonisation of units of work to address the SDGs, its processes, and teachers’ group engagements occurred in a cyclical and a complementary manner respectively, and constant reflection became imperative. Deep thinking and consideration were given to every phase of the PD of teachers, and reflections were most suitable to document these thought processes. Firstly, members of teacher groups shared their written reflections amongst themselves within their teacher groups. Secondly, reflections were submitted as a part of PoEs at the end of the module.

## 4.9 Data analysis

Creswell (2014) believes that a competent researcher collects and prepares data for analysis, then reads through and codes the data, he/she finally codes the text for description or themes to be used credibly in the research report. I used this understanding to create codes that formed categories for data, these categories were then put into themes that were reported as findings. Content analysis was used to interpret data obtained from this study. Content analysis is used to analyse documented information in the form of texts, media, or even physical items (Creswell & Poth, 2018). All the interviews in the study were recorded, transcribed, documented, and analysed. Creswell and Poth (2018) note that content analysis is usually used to analyse responses from interviewees. All micro-teaching presentations by teachers were observed, and observations were documented in observation schedules and analysed. The materials and resources that teachers used were compiled as PoEs and subjected to document analysis. Creswell and Poth (2018, p. 70) explain that the “purpose of content analysis is to organize and elicit meaning from the data collected and to draw realistic conclusions from it”. Denzin and Lincoln (2018) argue that content analysis in a study is one of the aspects that creates time structures for participants’ lives and experiences.

Following Gray (2016), I subsequently used thematic analysis for recognizing and analysing patterns of meaning in the data. Data was coded and put into categories and themes which added meaning to this study in the form of findings. I am reflexive about the tension of leaning on what Thambinathan and Kinsella (2021) refer to as Eurocentric paradigms. I am also conscious of and sensitive to the contradictions of leveraging constructs from colonial times to examine issues of knowledge and power using a decolonial lens. For example, thematic analysis (Gray, 2016), a distinctly Euro-western frame used to interpret data, was adopted for recognizing and analysing patterns of meaning in the data.

There is an absence of studies on discrete indigenous data analysis methods in the literature on Indigenous research methodologies. However, data analysis is occasionally incorporated as an aspect of Indigenised research frameworks (Elder & Kersten, 2015; Suaalii-Sauni & Fulu-Aiolupotea, 2014) or, more often, follows emic academic techniques mediated by etic values and paradigms (Gillies et al., 2014; Wright et al., 2012). This chapter proposes a hybridisation of oral culture practice and contemporary thought experiment. It is grounded in Aboriginal protocols of communal knowledge production that are aligned with principles of complexity theory. This type of analysis represents a significant departure from western academic approaches, while promoting

high levels of intellectual rigour. It also offers the intriguing possibility of examining non-indigenous data sets using an IK process, potentially resolving the issue described by Walter (2005) of quantitative data being, to date, largely ignored in indigenous research. Those principles are distilled here into the descriptors of connection, diversity, interaction and adaptation, sitting within a framework of pattern-thinking. They reflect indigenous ways of valuing, being, knowing and doing (Martin, 2008).

For Arshad (2020), decolonisation involves a critical analysis of how colonial forms of knowledge, pedagogical strategies, and research methodologies have shaped what we know and what we recognise. I also argue for inter-cultural dialogue (between IK and Euro-Western knowledge) and epistemological border-crossing research methodologies. I saw the value in approaching the analysis of data in this manner. I am of the view that not all ideas that originated in the global North should be shunned, but they should be explored on the merits of their functionality for purpose.

I refer to Prassada's (2019, p. 67) work on 'Discourses Analysis by a Decolonial Perspective', whereby she notes that:

This decolonial perspective gives power to the social and human sciences of today, since it allows thinking and producing knowledge about the long-term processes that cross-section people in the disputes over the "control of the basic areas of social existence and from whose results a pattern of power distribution centered on relations of exploitation /domination/conflict between the population of a society and in a given history is configured" (Quijano, 2000, p. 114). This allows thinking and rethinking reality transcending the "unique thought" of coloniality/modernity.

Taking the theoretical-methodological, ethical-political, and epistemological foundations of decoloniality, it is presented below what the analysis of discourses from decoloniality would be, in the overcoming of master-slave relations in a historical-social framework that contains both (who investigates as who is the subject of the investigation).

Inductive reasoning was then used to analyse the data in this study. Sauce and Matzel (2017, p. 2) state that "inductive reasoning is a logical process in which multiple premises, all believed true or found true most of the time, are combined to obtain a specific conclusion or to supply evidence for the truth of a conclusion." Feeney (2017) adds that inductive reasoning is used to make broad generalizations from specific observations, and conclusions are then drawn from that data. The

reporting in this study was based on what was observed and reported through each of the five data sets. Inductive reasoning arose as there was no preconceived ideology or framework from which to work because this study was based on exploring TPD on addressing SDGs using IK which was relatively novel.

Denzin and Lincoln (2018, p. 780) define coding as “the heart and soul of whole text analysis.” Coding forces the researcher to make judgments about texts, identify themes, and find relationships among codes (Denzin & Lincoln, 2018). I identified similarities in the responses of different teachers. I also observed similarities between what teachers said and what was presented in their PoEs and their micro-teaching presentations. Through these similarities, codes emerged inductively from the data. Open coding was used where I categorized the meaning of the text or segment from transcriptions that reflected the views of participants. Similar responses and observations were allocated the same code. Themes appeared when similar segments or codes were merged (Creswell, 2014).

All information from the data generation methods was represented textually and categorized thematically. Creswell (2014) asserts that the qualitative process of data analysis should be simultaneous. Different stages of the data analysis happened simultaneously. At times while I analysed an interview transcript, I noticed a theme that I had pondered about while I had been analysing data from an observation schedule. I examined both data sets which were obtained at different times in the study, simultaneously.

#### **4.10 Trustworthiness, Credibility, Dependability, and Transferability**

Cope (2014) notes that in qualitative studies issues of trustworthiness, credibility, dependability, and transferability are vital. Trustworthy studies not only demand the integration of multiple sources of evidence but the integration to continually take place over time (Cope, 2014). Trustworthiness addressed methods than can ensure one has carried out the research process correctly (Gunawan, 2015). The data production process in my study was carried out over time using multiple methods (FGIs, observations, reflections, document analysis, and recording of field notes). Creswell and Creswell (2017) note a complementary relationship between reflections, interviews, and document analysis that enhances the trustworthiness of findings. Data could be checked and validated by using multiple methods of data generation. Multiple data generation approaches could have either complemented one another or offered different dimensions of perceiving the phenomenon under

study (Creswell & Creswell, 2017).

Credibility according to Ghafouri and Ofoghi (2016) is described using the terms “authentic” and “accurate”, and whether the data and findings are suitable for the claims of the research. To enhance credibility, I consulted my pilot study and requested peer research students and academics who support postgraduate work to examine my instruments and advise on their suitability. I was as detailed and clear as possible in my reporting, only making claims which could be supported by the data I collected. I avoided unrealistic inferences.

Dependability according to Noble and Smith (2015) ensures that the research findings are consistent and can be repeated in a similar context. This is measured by the standard at which the research is conducted, analysed, and presented. Kyngäs et al. (2020) state that the purpose of qualitative inquiry is to assess the repeatability of results if the inquiry occurred within the same or a similar group of participants. Explicit descriptions and honest reporting in my study ensured that my findings were consistent and enhanced dependability. Member checking took place. Teachers were invited to review FGI transcripts to confirm that their responses were captured correctly.

Korstjens and Moser (2018) state that confirmability is the degree to which findings of the research could be concerned with establishing that interpretations of findings are derived from the data. Confirmability questions how the research findings are supported by the data collected. Confirmability seeks to gauge whether the researcher has been biased during the study (Korstjens & Moser, 2018). All biases were avoided as far as possible and when biases arose during this study, they were declared as such through my written field notes.

The degree to which the results of qualitative research can be transferred to other similar contexts or other participants is called transferability (Korstjens & Moser, 2018). The degree of transferability of the aspects of this study is dependent on the nature and similarity between the context of this study and other contexts. In this regard, I endeavored to provide thick and dense data descriptions and detail. The use of the semi-structured interview and observation schedules and audio-recorded textualized interviews allowed for the repeated revisiting of the data to check emerging themes and remain true to participants’ accounts of their experiences. The use of rich and thick verbatim extracts from respondents/interviewees, allowed for judgments to be made about whether the final themes are true to the participants’ accounts (Noble & Smith, 2015). To ensure rigour in this study I used thick descriptions which are transparent and explicit when reporting on the phenomenon being studied (Noble & Smith, 2015).

## **4.11 Ethical Issues**

Ethics refers to “mutual trust, acceptance, cooperation, promises, and well-acceptable conventions and expectations between all parties involved in a research project” (Strydom, 2011, p. 113). Macrina (2014, p. 18) offers the following criteria for ethical research: “integrity encompassing matters related to data generation, management, storage, sharing and using appropriate and respectful terminology during authorship and publication.” According to Resnik (2015), the code of ethics supplies the participants with details about what is intended to be done with the information that is given and it shows the intention to treat both the participants and the information with respect and honesty. Autonomy was ensured because only participants who voluntarily agreed to take part in this study were given consent forms. Key considerations to comply with research ethics are outlined next.

### **4.11.1 Gatekeeper permission to conduct the study**

I applied for ethical clearance from the Human and Social Sciences Ethics Committee of my university (Protocol reference number is HSSREC/00002271/2021 [Appendix F]). After obtaining permission from the registrar who is the gatekeeper at the HEI (Appendix H). This was necessary because data was generated from teachers who were enrolled to study the Honours module at the HEI.

### **4.11.2 Informed consent from participants**

Both the participants and the information they provided were treated with respect and honesty (Resnik, 2015) (See Appendix G). Written consent was given by teachers, this involved the procedure by which an individual may choose whether or not to participate in a study (Biros, 2018). Participants were informed that their participation was voluntary and that they could withdraw from the study at any time without negative consequences.

### **4.11.3 Anonymity and confidentiality**

Goosen (2018) states that the locations and names of individuals that participate in research should not be disclosed in printed or electronic publications and that details should be anonymised to maintain the participants’ trust. Brinkmann and Kvale (2018, p. 72) concur, stating that “participants’ right to privacy must be guaranteed”. In this study, pseudonyms were used to protect the identity

of participants. No data was attributed to any specific individual, instead, data was attributed to groups of individuals, thereby maintaining confidentiality. All data collected was stored securely and responsibly and will be disposed of after five years.

#### **4.12 Limitations of the study**

The findings of this research cannot be generalized because the research was conducted at only one university. Teachers studying at the HEI were not always available for the FGIs at the scheduled time. I made alternative arrangements to conduct the FGI which included, selecting two different groups of teachers for FGI and FGI2, and postponing and rescheduling meeting times to accommodate teachers who had challenges.

Indigenous knowledge holders have roles to play in the community. Teachers reported that setting up consultations and meetings with these IK holders was challenging. Teachers were advised to be as accommodating as possible and secure meetings in advance at locations most convenient to the IK holders. It became necessary for teachers to go into community settings in which the IK holders lived or practiced their various crafts, in some instances. Some groups could not get access to IK holders at all. Teachers were asked to share information amongst groups and to use referrals to recruit IK holders.

Keane et al. (2017) argue that much useful work has been done in IK–science curriculum integration, but that the research knowledge is available only to academics and not indigenous communities who are usually co-contributors to the research. To counter this, teachers and IK holders were invited to read the final dissertation report and view the developed resources.

Access to written resources to work towards decolonising units of work was a challenge. The literature review revealed a gap in opportunities to decolonise curriculums, especially within science and mathematics. The creation of decolonised resources from the beginning became time-consuming and challenging. I had to read extensively to address this challenge and asked participants to read widely on their chosen unit of work. I shared resources and readings with all teachers.

Another limitation of this study was the assumption that teachers will be passionate and robust about the need for decolonisation and addressing SD in the curriculum. Teachers, at times, were accepting of the current 'status quo' of teaching colonial-infused lessons and did not completely understand colonisation in science and mathematics. Popular perceptions were that concepts in

these subjects are proven and that proof formed within Western contexts is valid knowledge. I anticipated some form of resistance to the decolonisation process together with the underpinnings of this study. A discussion was held with participants and only those who were willing to participate (based on their valuing of a decolonial approach) were included in the interviews. Decolonisation of the curriculum is a fairly recent phenomenon and the practical implementation of it in the curriculum may be difficult to enact. However, teachers in my study attempted this by leveraging IK to address the SDGs.

#### **4.13 Conclusion**

This chapter discussed the methodology used for this study. The data generation methods and instruments used were described in keeping with methods of qualitative research. I explained the data generation steps methods and tools and justified their suitability of these by citing literature. I went on to discuss the use of the critical paradigm and the participatory research design. Finally, I discussed issues of trustworthiness, ethics, and the limitations and mitigation of these within the study. The chapter that follows presents a comprehensive analysis of the data collected and reports on the findings from this study.

## Chapter Five

### Data presentation and Descriptive Analysis

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## 5.1 Introduction

In Chapter Four, I theorized the methodological approach which informed my study. I generated data to explore how science and mathematics teachers address the SDGs by leveraging IK during their study of an Honours in Education module at a South African university. This chapter discusses the data generated and findings focused on descriptive analysis from the five data sets which are presented in Table 5 Below.

**Table 5**

***Schematic of the data generation process***

<b>Data Set</b>	<b>Data generation method</b>	<b>Explanation of data generation</b>
1. First data set	Focus group Interviews	Two sets of FGIs with six science and mathematics teachers studying an Honours in Education module respectively (Refer to section 4.8.2.3).
2. Second data set	Observations of Group micro-teaching presentations	Micro-teaching presentations by 12 groups (with 12 PoEs each) of teachers on how they plan to address the SDGs, leveraging IK through the teaching of a unit of work from the science mathematics school curriculum.
3. Third data set	Document analysis	Analysis of PoEs from each teacher group which included their CAPS and teaching and learning material analysis, lesson plans, PowerPoint presentations (Used in micro-teaching activity), extracts from CAPS Document and other supporting documents used for teaching and learning the unit of work.
4. Fourth Data Set	Teacher Reflections	I also analysed reflections from teachers which they recorded throughout their PD engagements and this study. These were submitted as a part of their PoEs.
4. Fifth data set	Field Notes	I generated field notes that were also used to supplement empirical data and add to the narratives of the teacher group engagements, I had observed, as well as discussions based on lectures presented during the Honours module.

Data based on the research questions that guided this study are reported in this chapter. I used an adapted version of the data analysis thematic framework as presented by Peel (2020) to guide my data analysis processes which are presented in Figure 15 below.

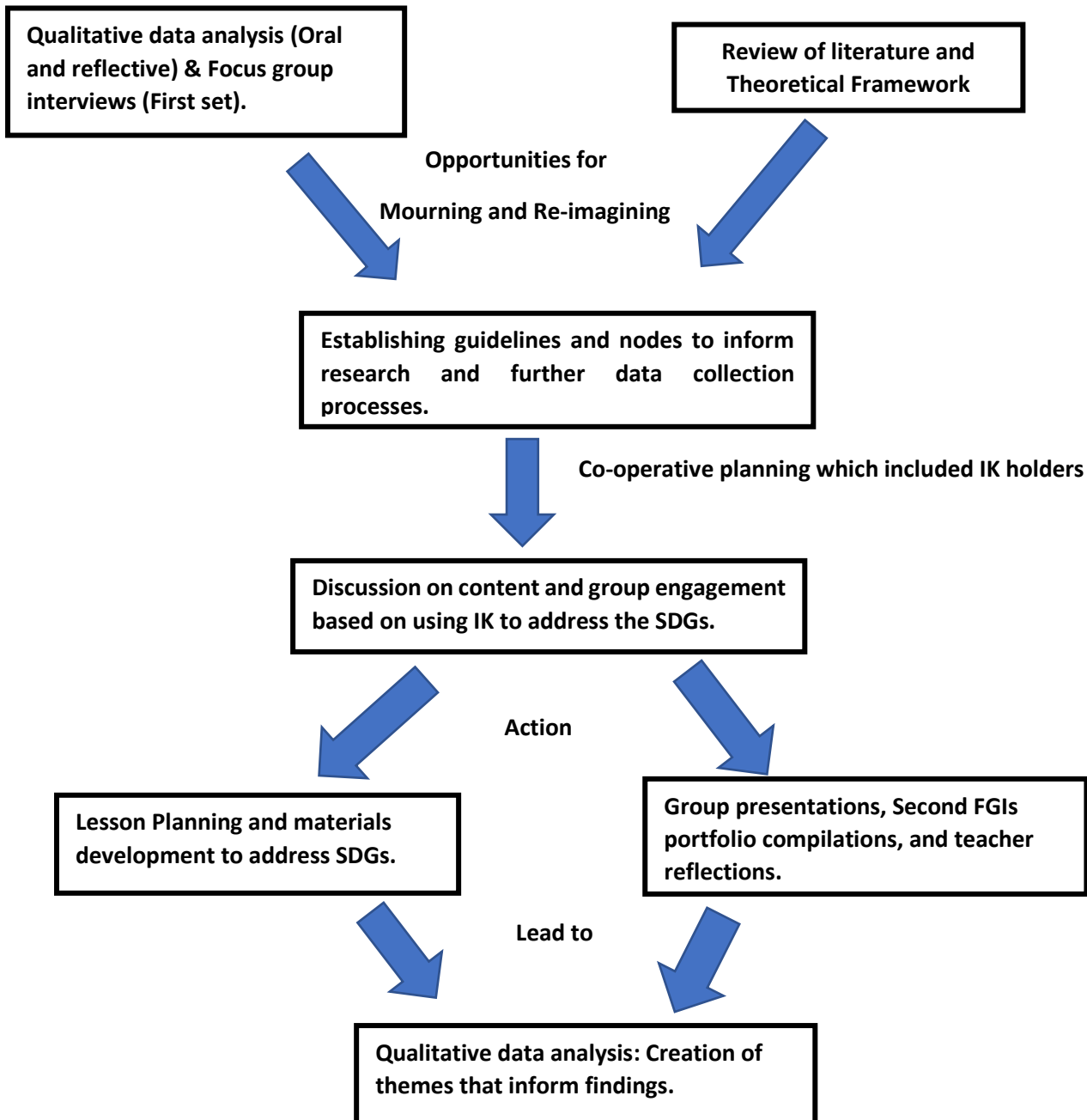


Figure 15: Data Analysis Thematic Framework (Adapted from Peel, 2020)

## 5.2 Presentation of Data and Descriptive (1<sup>st</sup> Level) Analysis

This chapter first presents data related to my research objectives which were documented by exploring teachers' experiences of addressing the SDGs by leveraging IK before they engaged with activities related to professional development in the module. I then present data related to the professional development activities in which teachers were involved and the strategies they employed to develop units of work that leverage IK to address the SDGs in the curriculum. I subsequently present data on the factors that enabled or obstructed teachers in their endeavor to decolonise the curriculum in the aforementioned ways, and finally I discuss how teachers responded to these factors.

The groups whose PoEs and micro-presentations I present in the data addressed similar SDGs. I report in this way for a more concentrated, depth of discussion. I show how different groups address the same SDGs in different ways to explore the depth of knowledge teachers developed.

There are also variations in the choice of SDGs groups chose to address in their unit of work. This showed the width of knowledge and skills that teachers developed through their professional engagements. I present an analysis of data from Groups Eight, One, Five, and Two. I focused on the work of these particular groups because they presented the most insightful, creative, and doable ways of incorporating IK to address SDGs which were relevant to the SA context. Group Eight addressed SDGs 3 and SDG 6. Group One addressed SDGs 1 and 15. Group Five also addressed SDGs 6 and 15. Group Two addressed SDGs 1, 2, and SDG 15. Three of the four groups addressed SDG 15 and two of the four groups addressed SDGs 1 and 6.

Data sources were represented with acronyms as follows:

Focus group interview 1- FGI1

Focus group interview 2 – FGI2

Micro-teaching Observation schedules - OS

Field notes - FN

Reflective journal – RJ

Analysis of PoEs- PoE/s

In each FGI, there were multiple questions. The code for a question was “Q” and the relevant number next to it reflected which question was referred to. E.g., Question ten from FGI1 is represented as follows, “FGI1-Q10”. Information from the analysis of OS and PoEs is followed by the teacher group number and the observation or document analysis was done as presented in Table 4 in Chapter Four. E.g., The acronym for the PoE of Group Two is presented as PoE2.

### **5.3 Research Objective One: To explore how science and mathematics teachers address sustainable development goals by leveraging indigenous knowledge.**

One major theme emerged from this research objective, namely:

#### **5.3.1 Theme One: Teachers addressed SDGs using IK in sparse, indirect ways**

This theme emerged from analysing transcripts from the FGIs and teacher reflections. The questions asked in the first FGI were based on understanding how teachers address the SDGs. The analysis of the FGI transcript for FGI1 and FGI2 (Appendix B2) for each teacher group and individual teacher reflections (Appendix E) was done. I also observed and analysed teachers' micro-teaching presentations (Appendix A1) and conducted document analysis on the PowerPoints teachers used (Appendix C) which they included in their PoEs. My field notes were also reported on as a part of the data. Responding to question five of FGI1, "Is sustainable development something that you are aware of? What does SD mean in the South African context?" Presh stated the following:

*I was only made aware of these goals recently. I had no idea of its existence before. (FGI1-Q5).*

Gift shared similar sentiments:

*I am aware of such a concept. How it is addressed, and its relevance to education and the South African context is not something that I am aware of (...) I got information about this from mainstream and social media platforms and educational conversations with other teachers (FGI1-Q5).*

It became clear that the SDGs were omitted during previous PD programmes in which teachers had engaged. As Gift stated, he was aware of SD. However, his knowledge was not constructed from a structured PD programme but from "media platforms and educational conversations with other teachers". Other teachers showed similar awareness about SD, but whether they obtained this from an educational or PD programme was unclear.

Thobisa stated:

*I was aware of sustainability; I also teach Agricultural sciences so in some concepts when I teach farming systems and methods (FGI1 -Q5).*

Question eight (a) of FGI1 delved into details of prior TPD. The question stated: “Have you been trained or offered professional development related to addressing sustainable development at an institution of learning?” Teachers' responses to this question are below:

*Presh: I have not been offered any professional development for sustainable development. Like I said I haven't even heard of it before (FGI1-Q8a).*

*Samuel: I don't think I was formally made aware or trained in addressing sustainable development. Maybe it was imparted somehow through the content but not formally (FGI1-Q8a).*

Nicki responding to this question said:

*No, I haven't been offered professional development like specifically about sustainable development (FGI1-Q8a).*

Teachers in this study indicated they had not been trained or offered PD related to addressing SD at an institution of learning. Therefore, addressing the SDGs in their teaching was limited. This recurring theme also emerged from the reflections that teachers presented. Thobisa, reflecting on his engagements in the module noted:

*At first, it was difficult to find ways and do planning which would achieve both curriculum (syllabus) and sustainable development (RJ - 04/04/2021).*

The difficulty that Thobisa (RJ - 04/04/2021) experienced in relating the curriculum to SD showed a lack of adequate knowledge and training (PD) related to addressing SD. When ascertaining if teachers leveraged IK to address the SDGs, teachers expressed constraints. In response to Q8 (b) Presh said:

*I have not been offered any PD for SD by leveraging indigenous knowledge. Is that even possible? (FGI1-Q8b).*

Samuel said:

*I was never aware of or trained in addressing SD through the use of indigenous knowledge (FGI1- Q8b).*

This lack of PD related to leveraging IK could be seen as a causal mechanism for teachers' limited inclusion of SD in the science and mathematics curriculum. Nicki viewed the exercise of incorporating IK into the curriculum as unfamiliar. She recorded the following as a reflection on 04/04/2021:

*This decolonial task to leverage indigenous knowledge to address the Sustainable Development goals seemed daunting as this unfamiliar territory in teaching, this is not something we think about generally when we teach (RJ).*

In the first FGI, participants were asked, "Do you address sustainable development by leveraging indigenous knowledge in your teaching?". Presh said:

*It is very limited. I do sometimes discuss indigenous structures when I teach shapes in Maths. I do speak about issues like poverty and unemployment as well, but not in detail (FGI1-Q12).*

Gift shared a similar sentiment in his teaching of Life Sciences:

*Not as much as I would like to. In some topics like respiration, one may speak about traditional foods and rural markets. But I do not do it as much as I could (FGI1-Q12).*

Thobisa concurred:

*I sometimes teach Agricultural sciences and discuss farming technologies, fertilizers, and traditional crops like sweet potatoes. I think it is limited to those topics. There are other topics where we cannot leverage indigenous knowledge to address sustainability issues (FGI1-Q12).*

The responses above revealed that teachers address the SDGs by leveraging IK in topics that are superficially limited to agriculture and IK due to a lack of training. This could be linked to a lack of professional development in this field. It was evident from FGI1 that teachers were not offered PD related to addressing the SDGs by leveraging IK. Teachers, therefore, leveraged IK to address SDGs in sparse, indirect ways.

**5.4 Research Objective Two: To explore: The pedagogical experiences of science and mathematics teachers who have engaged in PD activities in planning to address the sustainable development goals by leveraging indigenous knowledge in the school curriculum. (a) To explore the types of strategies science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address the sustainable development goals.**

Objective Two, part (a) sought to explore the types of strategies science and mathematics teachers use when leveraging IK to address SDGs in the school curriculum. Although the study of the Honours module constituted the PD that teachers engaged in, for my study, FGIs, meetings, and other engagements formed additional activities in which teachers engaged. Teachers were conscientized about curriculum decolonisation and SD, through the study of the Honours in Education module. During the study of the Honours module, teachers were also exposed to lectures and readings on decolonising the curriculum, and CDA (in March of 2021) to make visible concepts that are not readily seen or perceived (See Appendix D). The following themes related to strategies that teachers used to address SDGs by leveraging IK emerged.

Theme One: Indigenous Pedagogy and Content

Theme Two: Re-imagination and Enactment of a Decolonised Curriculum

Theme Three: Teachers enacted *Ubuntu-currere* through collaboration and challenging epistemic othering of IK

#### **5.4.1 Theme One: Indigenous Pedagogy and Content**

Commitment from members of the group became a powerful tool for the subsequent decolonisation process which was based on leveraging IK. Teacher groups engaged in and presented (in their PoEs) document analysis of the CAPS document and textbooks which they used to teach their selected unit of work during their study of the Honours module. Much of their analysis was done using CDA which they had learned about in the module, which constituted an activity of professional development (FN- 01/11/2021). Teachers showed commitment to adopting indigenous strategies when leveraging IK to address SDGs. These took two forms:

## **(One) Strategies related to indigenous pedagogy and, (Two) indigenous Content advocated**

Indigenous pedagogy advocated by the teachers were the strategies and teaching methods that IK holders and teachers (drawing from learnings during their PD) proposed.

### **5.4.1.1 Indigenous Pedagogical strategies advocated by teacher groups**

To understand the indigenous pedagogy advocated by teacher groups, I analysed FGI responses from teachers (Appendix B2), their presentations during micro-teaching which I observed (Appendix A1), and teacher reflections (Appendix E). The IK holders offered insights that were discussed within the teacher group engagements and captured in teachers' responses through the various data collection methods mentioned in Table 4. Document analysis of PoEs developed by the 12 teacher groups (Appendix C) also assisted in understanding the pedagogies used. Materials such as teacher document analysis, lesson plans, reflections, and supporting documents contained information about the pedagogy that teachers advocated for.

#### **Pedagogical Insights from FGIs**

It was refreshing to note that IK holders were incorporated into the study as valued, pedagogical practitioners working collaboratively with teachers. This was part of the PD as an intervention (Appendix D). This was also a testament to the commitment that teacher groups had toward exploring indigenous pedagogy. Responding to Q10, of FGI2, which stated "How were your experiences working with the indigenous knowledge holder? Did you obtain any insights related to leveraging indigenous knowledge to address the Sustainable Development Goals? Please elaborate." The following pedagogical references came through from teachers:

*I approached an Artisan to talk to him. I asked him to help me with my lesson plan and how to incorporate it into my lesson (Precious, FGI2-Q10).*

From interactions with Precious, it was revealed that the Artisan (who served as an IK holder) was a jewelry artist who made indigenous jewelry which he sold in an informal market-place. Lesson planning is a pedagogical exercise carried out by qualified educators. Precious' group engaged in transformative pedagogical practices by getting the IK holder to help them plan the lesson. Essy furthered her indigenous pedagogical advocacy by inviting the IK holder to teach with her group during the micro-teaching lesson (OS5). Also responding to Q10 of FGI2, she said:

*(...) the female elder I was working with was very rich in knowledge about soil fertility. She used cow dung and domestic excrete, or cattle dung. She creates troughs and mix them into the soil. Another form of fertilizer is using dry hay or grass for mulching, this supplies compost to the soil. She was warm and welcoming to my learners and patient too (Essy, FGI2-Q10).*

Essy took the IK holder into the classroom and included the latter in team-teaching or in this context, Ubuntu-teaching, which can be seen as an unconventional yet indigenous pedagogical practice. Admitting the IK holder into the classroom reflected Essy's agency and was not a requirement of this study or the study of the Honours module.

The teachers were also asked, "What do you think about including indigenous knowledge content and knowledge from the indigenous knowledge holder in this task?" (FGI2-Q11). Will explained:

*(...) the IK holder also gave us pedagogical knowledge like storytelling and narrative teaching approaches (FGI2-Q11).*

The IK holder offered methods of teaching that are in line with indigenous practices and ways of knowing which were not presented previously in teachers' teaching. Kaya (2013) noted that storytelling and narratives were used by indigenous populations to transfer knowledge from older generations to the young which ensured that cultural and ancestral importance and traditions were not lost.

### **Pedagogical strategies adopted during micro-teaching**

I observed the micro-teaching activity by Group One (made up of three Life Sciences teachers and an IK holder). They selected the topic 'Cellular respiration' and incorporated IK based on the fermentation of Zulu beer or "umqombothi" and some information on "Kefir". Their micro-teaching presentation took place at 10.25 am on 04/08/2021. They designed the lesson to address SDG 1 (No poverty- generating income by selling the Zulu beer) and SDG 15 (Life on Land – Sustainable use of plants and other organisms to produce the Zulu beer). Observation guideline 10 (Appendix A1) focused on pedagogy and teaching approaches to be used within a classroom setting. Below is the extract from Group One's micro-teaching presentation.

<b>10. Pedagogy and Teaching Approaches to be used.</b>	Teachers stated that storytelling and explanations of the traditional practices using Sorghum beer will be conducted when teaching the unit of work.
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**Figure 16: Extract from observation schedule about pedagogy used by Group One (OS1)**

Storytelling was a popular feature as a form of indigenous pedagogy that teacher groups adopted. I observed the group advocating for collaborative and cooperative learning strategies.

Group Ten presented a mathematics topic “Functions and Relations” from the Grade 8 CAPS curriculum. This observation took place on 12/08/2021 at 14h00. Group Ten incorporated IK by using the indigenous team game called “Three Tins” (teaching about “dependent” and “independent” variables related to the number of tins knocked down in the game by each player). They also included the Mandala (Patterned Artwork) around Baobab trees which are typically found in African countries. A number of these trees are cut down per year. The use of play and games as a pedagogy proposed by the group addressed and promoted SDG 17 – Partnerships for change. The care for nature and plant life (Baobab) addressed SDGs 13 (Climate Action) and 15 (Life on land). Below in Figure 17 is an extract from observations (using OS10) of the micro-teaching activity by Group Ten.

<b>10. Pedagogy and Teaching Approaches to be used.</b>	<p>Used the play approach to keep learners interested and informed. Collaborative learning, learners play in groups.</p> <p>Explanations and discussions also used.</p> <p>Resource based learning.</p> <p>Use multiple resources, pictures, diagrams and videos in the presentation.</p>
<b>11. General Observations/Notes/ Points of interest. (Focus on aspects of leveraging indigenous knowledge to address the Sustainable Development Goals)</b>	<p>Very creative and innovative presentation. Focused on playing games. Novel.</p> <p>Would use diagrams and videos to address the SD challenges and promote awareness in the lesson.</p>

**Figure 17: Extract from observation schedule about pedagogy used by group Ten (OS10)**

Group Ten's micro-teaching presentation provided evidence of how the IK was included through the use of games. Learning through play appeals to grade 8 learners because they are younger. The group proposed the "Three Tins" (a game where three tin cans are stacked and knocked over, with a ball made from reused paper and plastic [re-use of materials as a sustainable practice]) as an indigenous example. Three tins as a team game informed the use of play and collaborative learning to teach the unit of work. This presentation also highlighted the fact that multiple indigenous strategies can be used to address the SDGs when teaching a mathematics unit of work.

### **Pedagogical Insights Expressed in Teacher Reflections**

A few pedagogical insights were noted from reflections that revealed that science and mathematics teachers were committed to exploring indigenous pedagogies in the form of pedagogy through play to address the SDGs in the curriculum. In Dwayne's reflections, the following was noted:

*Using indigenous games was a way of showing learners that mathematics stems from our elders (...) They have been playing games like 'IN' (played with numbered shapes) and 'Mlaba-laba' (played with tokens and angels, which is compared to cattle herding by indigenous communities), such information was shared by elders in the community. Therefore, this brings a call to invite learners' parents and grandparents in our classrooms (RJ-15/04/2021).*

Dwayne reflected on collaborative and team-teaching pedagogies where a teacher can be an elder or parent as defined through a decolonial lens and not by an educational qualification as decreed to be the only legitimate marker of a teacher by the Euro-Western convention. Dwayne's view to include "learners' parents and grandparents in our classrooms" is consistent with Reade et al.'s (2013) contention in their paper on "Educating Global Citizens for the 21st Century" which is premised on teachers collaborating with outside experts and community members (like parents and grandparents) on programmes to benefit the greater good of education that transcend formal roles and responsibilities. The decolonial project and SD agendas are programmes that resonate with the 21<sup>st</sup> century learner. Reade et al. (2013, p. 113) believe that:

*the changing realities of our complex global society mean that colleges and universities must improve their ability to educate globally competent citizens for the 21st century—people who are informed about pressing issues and engaged in*

addressing those issues—who can exercise responsible leadership to promote positive change and build a sustainable world.

Thobisa involved the IK holder within the lesson planning phase which formed an important part of the pedagogical process:

*I consulted one of my community elders who does beadwork and sells it. I did a lesson plan before I consulted indigenous knowledge holder. I then, re-did my lesson plan as more indigenous ideas were left out which could have been used (RJ-06/04/2021).*

Thobisa's PD revealed a growing commitment to the pedagogy he advocated for. Thobisa's reflection taught me the importance of collaborative engagement when developing lessons. It also showed the importance of teacher's reflecting on their lesson planning and professional practices especially with other members of society who show an interest in the educational system.

Sbu extended the notion of collaborative teaching as an indigenous pedagogical approach, as indicated in his reflection below. He believed that teaching a unit of work with the IK holder was a strategy that could work well when applying IK to address the SDGs. This is especially significant to address SDG 17- Partnerships for Change. The enactment of this was in the IK holder's involvement in planning the lesson with Sbu where an educator and an IK holder can both play the role of teacher and contribute to the planning and teaching of a unit of work:

*I explained to her (IK holder) that I want her to show my learners how she makes traditional fertilizers for her garden and indicated that learners will be working with her following her lead and instructions. She was very delighted to participate in our excursion lesson she maintained that learners would see that what they learn at school is what they practice at home (Sbu's RJ – 04/05/2021).*

Sbu not only asked the IK holder to teach collaboratively with him, but he and the IK holder took learners on an excursion to explore agricultural practices that indigenous people adopt. This is an example of the innovative pedagogy that some teachers used. Indigenous pedagogy was one of the strategies teachers used to address the SDGs in the curriculum. Each teacher group presented how they plan to teach a unit of work from either the science or mathematics curriculum by leveraging IK to address the SDGs. In addition to advocating for including indigenous ways of learning, teachers also focused on content sourced from IK.

### 5.4.1.2 Indigenous Content advocated by teacher groups

Science and mathematics teachers were also committed to including indigenous content as a strategy to address the SDGs in the school curriculum. This section shows the types of content that teachers included in their units of work. Furthermore, in section 5.4.2.2 below, teachers enacted a decolonised curriculum that addressed the SDGs through the analysis of a unit of work in CAPS to reveal opportunities for incorporating IK, and the decisions on what content to include will be presented. An analysis of teachers' PoEs revealed the inclusion of indigenous content that teacher groups included.

#### Evidence from Document analysis transcripts

The science and mathematics teachers conducted literature searches and contributed information related to indigenous content within their units of work. Below are some examples of these.

Group Eleven addressed the topic, “Water availability and quality” from the Grade 11 Life Sciences curriculum. They explored indigenous strategies for water purification to address SDG 6 – the ‘water goal’ – to ensure the availability and sustainable management of water and sanitation for all. They also addressed SDG 14, which alludes to Life under water. Indigenous content from Group Eleven’s PoE is shown below in Figure 18. The group included indigenous content related to water storage, water management, and irrigation methods. They cited the indigenous “khattara” system of transporting water underground, and the use of clay pots and wooden pivot methods to teach their unit of work.

“Indigenous knowledge of water resource management and irrigation methods vary from canal, pond and well digging, khattara, open-surface irrigation, spate, under-surface and covered tunnel, buried clay pot, pitcher, wheel, wooden pivot methods, construction of bund around fields and cultivation of low moisture adaptive crops. Farmers’ knowledge of plant-soil-moisture relationships and adaptive capability of domesticated plants also play a significant role in the evolution of indigenous irrigation and water resource management methods.” These are some examples and

**Figure 18: Extract from PoE11**

Group Eleven committed to exploring content related to indigenous forms of “water resource management” to be included in their unit of work. Group Eleven planned to address SDG 6 and 14 in the following ways:

*SDG 6 – the ‘water goal’ – to ensure availability and sustainable management of water. Through localised water purification methods and to save water using sustainable local means like using catchment tanks to store water making it available for the community. Also installing sand dams without the use of chemicals which may get into the Hydrosphere and poison organisms (linked to SDG 14) living in water. (PoE11).*

Group Two examined Geometric patterns – Grade 6 from the mathematics curriculum. The group incorporated IK related to African artwork, ornaments, and jewelry to teach Geometric patterns. The unit of work addressed SDG 1: No poverty, SDG 2: Zero Hunger, and SDG 15: Life on Land. Below in Figure 19 is an extract from the PoE that Group Two presented.

Western knowledge of patterns as a topic within mathematics curriculum is taught in relevance to African context. Zulu baskets, Ndebele wall paintings and fabrics are part of art work done by people of Africa for commercial and decoration purpose. These skills develop and boost different communities’ economy by attracting tourists (Mosimege, 2017). An example of this was in a learners’ activity in (Bowie, et al., 2012, p. 65) Platinum Mathematics textbook as depicted in the picture below. There are two games commonly known as ‘IN’ and ‘Mlaba-laba’ respectively. These games can be

**Figure 19: Extract from Group Two’s POE (PoE2)**

The group included content related to the unit of work from the game “IN” typically known as “Hopscotch” which is a game, played with numbered shapes. They also included “Mlaba-laba”. From IN game, teachers can extend the diagrammatical view/representation of the game by asking learners how many squares or rectangles are needed to double/triple the diagram. In the Mlaba-laba games, learners are taught about symmetries as a sub-topic within Geometric patterns. Moreover, learners can find the rectangles/squares that are repeated against the number of circles found if further rectangles/squares are to be added:

*These games are typically played with learners chanting indigenous folktales and poems which have an important life lesson attached to it (PoE2).*

The content that teacher groups were able to present was informed by their commitment to looking at indigenous content as a strategy as shown in the literature they presented. The exploration of information on indigenous games and artwork, the explanation of the structure of these, and the reasoning behind it contributed to the content used in the unit of work.

Group Two planned to address SDG 1, SDG 2, and SDG 15 in the following ways:

*SDG 1 and SDG 2 will be taught to learners in the context of beadwork, artwork, and fabrics can be sold and also form a part of tourism economies where tourists are trained on how to create them and taught about the indigenous significance of it. These form a part of job and skill creation opportunities allowing indigenous people to feed their families. SDG 15: Materials used in beadwork and mats can be natural seeds or recycled materials (that would otherwise be disposed of in landfills) used responsibly to benefit human beings while caring for the land (SDG15) (PoE2).*

Group Twelve reviewed a Natural Sciences unit of work where they planned to teach a Grade 9 topic, “Water purification” which is linked to the broader topic of “Pollution of water resources” in the CAPS document (DBE, 2011, p. 80). The group explored indigenous ways of purifying water by addressing SDGs 3 and 14. Figure 20 below shows a discussion of the literature related to indigenous water purification methods they advocated for and included in their unit of work.

A study conducted by Tiwari (2016), ‘*A Review on Traditional Water Purification Methods*’ used in Rural Areas in India provides insight on how indigenous people have always been cognizant of conventional water treating methods. These methods were used before Western methods were adopted and are still used to remove impurities from water. Traditional water purification methods include boiling, filtration, sedimentation and solar radiation and use of *Moringa Oleifera* seeds. Boiling is an effective way to destroy water borne diseases causing agents that are present in water. Filtration is an economical way that assists in removing wind borne pollutants such as leaves and coarse particles from water. Sedimentation is useful for the removal of turbidity and pathogenic bacteria whereas solar disinfection (exposing water to sunlight) destroys most germs that cause disease. According to our IK holder, all the mentioned methods were used in households before contemporary methods were introduced.

**Figure 20: Extract from Group Twelve’s PoE (PoE12)**

In addition to literature of ‘Traditional Water purification Methods’ Group Twelve also reviewed literature by Delelegn et al. (2018) where they learned about how the the dry seeds of *M.oleifera* are used in place of aluminium sulfate by rural women of Ethiopia to treat highly turbid water from Nile River. When the crushed seeds are added to raw water, the proteins produce positive charges acting like magnets and attracting the predominantly negatively charged particles (such as clay,

silt, bacteria and other toxic particles in water). The group also read about 'Water Storage' by Purohit (2015) where they learned that in the past when people did not have water filters and refrigerators, water was stored in clay pots. In some rural areas, people still use clay pots as a traditional way of storing drinking water. This method was common in Africa and India. The benefits of storing water in clay pots include keeping the water cool naturally due to the tiny air pores present in them, are affordable, save energy and are eco-friendly when compared to refrigerators (Purohit & Taylor, 2015).

Teachers used IK through the notion of cultural border-crossing with the Euro-Western knowledge that may already be present in the curriculum. It is important to note that teachers retained the information present in the CAPS document, textbooks, and support documents (some of which were colonial forms of content) and included indigenous knowledge from the literature they had perused. The group used the following concepts from the CAPS document:

*The hydrosphere, water forms, water purification techniques using chemicals. The requirements for sustaining life. Living things need clean water to survive (DBE, 2011, p. 17) (PoE12).*

This unit of work was identified to be linked to SDG 3: Good health and well-being and SDG 14: Life below water:

*When people get sick from consuming contaminated water, it interferes with the achievement of SDG 3 that promotes good health for every citizen. This has a negative effect on health of people and organisms living in that water (SDG 14) who cannot access clean fresh water. Therefore, it is essential that people are educated about other alternatives for water treatments that could be achieved at home, as well as alternative ways for water storage that promote good health (PoE12).*

Group Twelve included traditional purification and storage methods like boiling water and the use of Moringa seeds which were fundamentally different from the chemical purification techniques (DBE, 2011), presented in the CAPS document on the unit of work. Teachers reviewed literature and did not depend solely on knowledge from IK holders. Jautse et al. (2016) note that epistemological border-crossing between Euro-Western science and IK can only be done smoothly if teachers have the sufficient pedagogical and content knowledge to do so.

## 5.4.2 Theme Two: Re-imagination and Enactment

The teacher groups further engaged in Chilisa's (2012) stages of decolonisation and re-imagined and enacted a decolonised curriculum as strategies to leverage IK and address the SDGs. This theme can be linked to Chilisa's dreaming and action. Re-imagination was evident from the teachers' responses in their reflections and FGIs.

### 5.4.2.1 Re-imagining a decolonised curriculum

How teachers re-imagined the curriculum informed how they enacted it.

#### Evidence from Reflections

Reflections done by teachers throughout their PD activities were documented which included their ideas and imaginations of what teaching using a decolonial lens could be. This is equivalent to Chilisa's "dreaming" stage of decolonising the curriculum. Teachers' "commitment" (Chilisa, 2012) to this work was evident by the details and frequency with which they documented their reflections. An extract from Gift's reflection revealed his re-imaginings:

*The idea was also to show that our indigenous knowledge systems and local knowledge producers are as good and effective as those from Europe. Thus, putting a stop to epistemic violence – the silencing or ignoring of knowledge and beliefs produced by the others (RJ – 08/05/2021).*

Gift presents his ideas and aspirations related to "local knowledge being effective" enough to teach and "putting a stop to epistemic violence – the silencing or ignoring of knowledge and beliefs produced by the others" reflects a re-imagined, decolonial curriculum. Gift was exposed to terms such as "*epistemic violence*" and "*knowledge producers*" from his engagements with the Honours lectures which formed a part of the PD activities. These terms were interrogated during one of the Honours lectures (FN -01/04/2022).

Dwayne re-imagined who the "legitimate" teacher is by inviting learners' families and community members to the school to share their IK and include them in the curriculum decolonisation processes:

*Therefore, this brings a call to invite learners' parents and grandparents in our classrooms when we teach because this notion of integrating indigenous knowledge to the curriculum involves all people (RJ - 15/04/2021).*

Dwayne's reflection expressed a re-imagined Physical Sciences curriculum where multiple stakeholder engagements for which collective pedagogical practices are motivated. The call for the "curriculum involves all people" was an idea that Dwayne perceived as worthy of consideration.

### **Evidence from FGI2 on teachers' commitment to re-imagining (dreaming of) a decolonised curriculum** (FGI2- took place after teachers engaged in professional development)

The FGI2 revealed more streamlined visions and dreams shared by teachers. Teachers participated in activities toward their PD within their study of the Honours module. Precious showed dreaming related to curriculum structure and development. When asked (Appendix B1, Q8) "Explain if indigenous knowledge can be leveraged within the science or mathematics school curriculums. Can indigenous knowledge be leveraged to address the Sustainable Development Goals within the science and/or mathematics curriculum?", she said:

*Like if it was incorporated in the CAPS document, like these are the indigenous knowledge topics you can use to teach these concepts. Like that would really help like any teacher on the field (...) So, if it could be streamlined and incorporated into the curriculum or maybe just have like a side document for teachers then that would really help (FGI2-Q8).*

The aspiration for the curriculum to be "streamlined" where she says, "*like these are the IK topics you can use to teach these concepts*" expresses a desire for a different curriculum where IK is considered an important factor, and not just an "underlying principle" as specified in the CAPS document (DBE, 2011, p. 11). Precious desired some learning and teaching support material in the form of documents. This is evident in the statement "*side document for teachers then that would help*". Cat supported the aspiration of having IK and SDGs explicit within the curriculum. This was a very important reflection especially if curriculum designers are serious about a decolonial curriculum that focuses on ESD. I present an extract of her response to Q8 of FGI2:

*Yes, it can be incorporated but it is not something that can be done overnight, it is going to take a lot of time. And as it was said, it is something that needs to be included in the CAPS (FGI2-Q8).*

Cat may have not known the exact nature of how IK can be leveraged to address the SDGs, but she desired information on “*it*” (refers to content on SDGs and IK) to be “*included in the CAPS or the curriculum*”.

Dwayne extended his vision beyond the curriculum document to examine resources, textbooks in particular. He also responded to Q8 of FGI2 below:

*Yes, indigenous knowledge can be leveraged in the curriculum, not in its entirety, however, many current textbooks serve to incorporate indigenous knowledge into subject material but does not promote knowledge of the Sustainable Development Goals which would assist in addressing these goals (FGI2-Q8).*

Le Grange (2016) posits that dreaming involves colonised people retrieving their indigenous knowledge systems to theorize and imagine alternative possibilities for the curriculum using a decolonial lens. Dwayne re-imagined using the opportunities for the use of IK found in textbooks to “transfer and promote knowledge of the SDGs (in the classroom?) which would assist in addressing these goals”.

#### **5.4.2.2 Enactment of (Action towards) a decolonised curriculum**

In my study, teacher groups first selected topics in the CAPS document and then narrowed their focus onto a unit of work they could teach by identifying opportunities where IK could have been leveraged for the SDGs to be addressed. I present extracts from teachers' PoEs I reviewed to understand the action (Chilisa, 2012) strategies teachers used. I present extracts from teachers' lesson plans, textbook extracts, and extracts from LTSM (including worksheets, teacher analysis, and teacher notes) to reflect units of work from the four subjects. These are Life Sciences, Mathematics, Natural Sciences, and Physical Sciences. Teachers leveraging of IK to address SDGs was also evident from the group micro-teaching activities which were observed using Appendix A1 and analysed. Information from micro-teaching presentations is included in the “Observation extracts and discussions from teacher group presentations” (Appendix A2) and was important to my analysis of the data.

My analysis revealed two categories of enactments of a decolonised curriculum by teacher groups based on content used IK to address the SGDs in units of work.

- i. Deconstruction of different teaching materials presented in PoEs (CAPS, lesson plans, and support materials) through document analysis, using a decolonial lens. This also entailed the addition of a summary of indigenous knowledge and SDGs to existing information to be given to learners as notes/a resource.
- ii. Reconstructed lessons that specified incorporation/leveraging of IK content and addition of notes containing IK to address SDGs used to supplement teachers' lessons. An observation schedule (Appendix A1) was used to record the insights about ESD and IK that were used in units of work presented in teacher group presentations (FN-02/01/2022).

The sub-headings below (a. to e.) present the enactment strategies that teachers committed to and presented in their PoEs and their micro-teaching presentations. The strategies were what teachers were taught during their professional development as discussed in Appendix D (summary of PD activities). Before their PD in this study teachers' address of the SDGs, using IK was vague, as presented in section 5.3.1 of this chapter. After teachers engaged in their PD, they were able to draw on strategies to enact a decolonised curriculum to leverage IK and address the SDGs. I present these sub-headings within examples from the Physical sciences, Life Sciences, Natural Sciences, and Mathematics curriculums (across the General Education and Training [GET] and FET phases) for a holistic discussion of how teachers decolonised the curriculum and addressed the SDGs.

Teachers' enactments were organized into the following themes for analysis: *Deconstruction of curriculum materials*, *Teacher learning*, and different approaches to the *reconstruction of curriculum materials*. This linearity is intended for ease of reading, but each of the three processes evolved iteratively. I begin by presenting a table showing the "Summary of the micro-teaching presentation by each group". I then present sub-headings (linked to the criteria I used within my document analysis [which are presented in Appendix C] for a consistent understanding of the data) which guided my analysis. These sub-headings are:

**a. Deconstruction of a unit of work in the curriculum by Group**

**b. Group's Critical analysis of textbook materials**

**c. Teacher learning from IK holder**

**d. Teacher learning from self-directed research**

## e. Reconstruction of unit of work

### e1. Knowledge of the ancestors with associated examples of decolonised activities that Groups presented

### e2. Achieving SDGs

The data below shows how teachers enacted a decolonised curriculum that addressed the SDGs as it was captured from their PoEs. Further discussions of the enacted decolonised curriculum from each group presentation are in “Appendix A2: Observation extracts and discussions from teacher group presentations”.

#### (i) Example from the Physical Sciences Curriculum

Table 6 below shows the CAPS unit of work selected by the teacher group, the IK included in the planning of the lesson, and the SDGs they plan to address. This table supplements the biographical detail presented in Table 3 (presented in Chapter Four).

**Table 6**

#### ***Summary of Micro-teaching Presentation Group Eight: Physical Sciences***

<b>Grade Unit of work</b>	<b>IK content</b>	<b>Indigenous pedagogy</b>	<b>SDGs</b>
Grade 10: Hydrosphere	a. Traditional water purification methods include boiling, filtration, sedimentation, solar radiation, and the use of Moringa Olefeira seeds. b. Storing water in clay pots. c. The use of indigenous catchment methods and underground indigenous water harvesting technologies.	This included the idea of bringing in a local IK Holder who had knowledge of traditional water purification methods in his/her planned unit of work.	SDG 3: Good health and Wellbeing SDG 6: Clean Water and Sanitation.

(Source: OS8)

### a. Deconstruction of a unit of work in the curriculum by Group Eight

Group Eight comprised the following teachers: Dwayne, Cat, and Nkunzi (IK holder) who critically analysed the Physical Sciences topic “The Hydrosphere” in Grade 10. Below is the CAPS document extract they presented in which their unit of work was located (Figure 21).

GRADE 10 CHEMISTRY (CHEMICAL SYSTEMS) TERM 4					
Time	Topics Grade 10	Content, Concepts & Skills	Practical Activities	Resource Material	Guidelines for Teachers
8 HOURS	The hydrosphere	The hydrosphere consists of the earth's water. It is found as liquid water (both surface and underground), ice (polar ice, icebergs, and ice in frozen soil layers called permafrost), and water vapour in the atmosphere.			The focus of this section should not be the chemical equations or any rote learning, but should encourage application, interpretation, and environmental impact.
	Its composition and interaction with other global systems.	<ul style="list-style-type: none"> <li>Identify the hydrosphere and give an overview of its interaction with the atmosphere, the lithosphere and the biosphere. Water moves</li> </ul>	<p><b>Activity:</b></p> <p>Study the ecology of the dams built to provide water for communities</p> <p>For this activity learners will</p>	<p><b>Materials</b></p> <p>Use TETRA-test strips to test for water (buy from pet shop for fish tanks). Silver nitrate, microscope or magnifying glass, filter paper and funnel.</p>	<p>The hydrosphere is not a global cycle.</p> <p>The emphasise should be on the CHEMISTRY of the hydrosphere.</p>

**Figure 21: Extract from Physical Sciences Grade 10 CAPS document (DBE, 2011, p. 60) (PoE8)**

This group was able to use critical discourse analysis (CDA) to look at the strong focus on Euro-Western technological advancements like “TETRA-test strips” and purifying techniques which included the use of “filter paper and a funnel” as opportunities in which indigenous ways of water purification could be introduced. Under the “Guideline for teachers” section, teachers identified “environmental impact” and saw this as the perfect opportunity to bring in the SDGs.

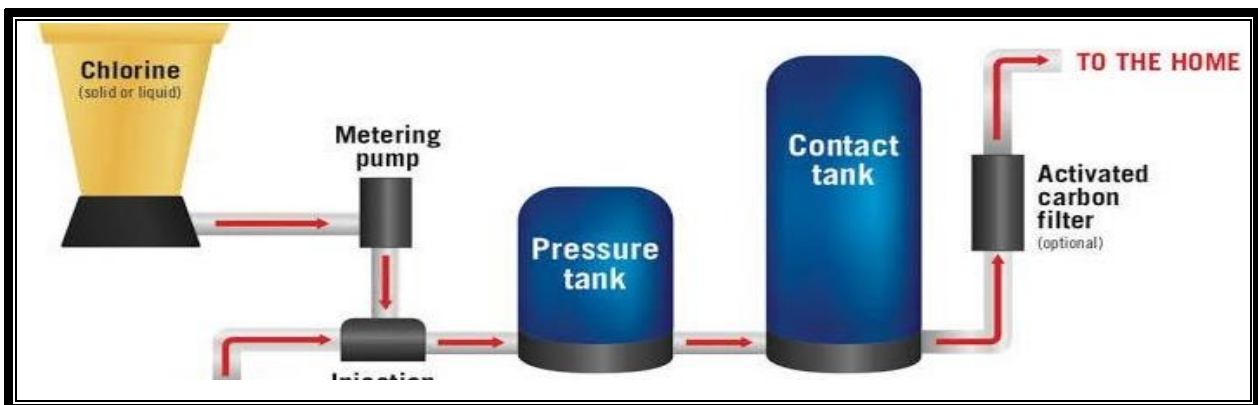
The PoEs that teachers submitted were compiled based on prescribed criteria. Teachers identified evidence of colonial ideologies present in their selected units of work (from textbooks or other LTSM). They then decided on IK which can be linked to SDGs and included information based on this. Smith (1999) notes that Identifying elements of colonisation in a unit of work, extracting and scrutinizing these to find gaps where opportunities for the action of introducing decolonised elements (IK) are necessary to the decolonial process.

#### **b. Critical analysis of textbook materials (Group eight)**

The group's analysis revealed that most information sources like textbooks and internet websites perpetuated the idea that water treatment methods were first developed in Western countries. Below is an analysis they provided in their PoE:

*According to Enzler (2018), a Greek scientist Hippocrates 'discovered' the healing powers of water. He then invented the practice of sieving water, and obtained the first bag filter, which was called the "Hippocratic sleeve". This strongly emphasized the contributions made by Western scientists in water treatment, namely Archimedes, Sir Francis Bacon, and many others. No African scientist or any African techniques are mentioned in Enzler's (2018) article (PoE8).*

*The omission of the contribution of African ideas and methods is evidence enough that they are regarded as inferior and inadequate whereas those of the west is superior and efficient. In the two Grade 10 Physical science textbooks that the group used, namely, "Study and Master Grade 10 Physical Sciences" and Oxford "Physical Sciences for Grade 10", the Hydrosphere was covered drawing on Euro-Western contexts (PoE8).*



**Figure 22: Water Purification cycle steeped in Euro-Western epistemologies (PoE8)**

*The use of industrialized chemicals like Chlorine and Carbon filters coupled with the tanks and fuels consuming pumps seem to contribute to an unsustainable, colonial process, different from what IK and sustainability motivate for (PoE8).*

**c. Teacher learning from IK holder:**

*I observed one of the meetings between members of Group Eight and the IK holder on Nkunzi (IK holder). Nkunzi described indigenous ways of water storage and purification which teachers included in the activity. An important outcome of this meeting was that Nkunzi stated that Moringa seeds and storage of water in clay pots were indigenous water cleansing practices and should be included when planning the unit of work on the Hydrosphere. Clean water is one of the goals of sustainability (FN – 20/06/2021).*

#### **d. Teacher learning from self-directed research**

Teachers researched indigenous methods to purify water sustainably by tapping into knowledge from the community. From my document analysis of Group Eight's PoE, the following was identified:

*According to our reading from Delelegn et al. (2018) and Purohit (2015) there exists other traditional water purification methods which include boiling, filtration, sedimentation, solar radiation, and the use of Moringa Oleifera seeds. According to our grandmothers and other elders, all the mentioned methods were used in households before contemporary methods were introduced (here they included anecdotal evidence from the IK holder they selected as a group) PoE8.*

The group included information they read about and obtained from Nkunzi in PoE8 to develop the unit of work on "Water Purification". The following was included in their lesson notes and presented during their micro-teaching session:

#### ***Use of Moringa seeds (Water Purification)***

*Moringa Oleifera Lam belongs to the family Moringaceae and is found in many countries of the tropics. It is reported that when the crushed seeds are added to raw water, the proteins produce positive charges acting like magnets and attracting the predominantly negatively charged particles affecting the pH of the water. Heavy metals in water with a lower pH tend to be more toxic, as they are more available to the body. A high pH would make heavy metals less available, and, therefore, less toxic. Taken together, the seed powder exhibits a remarkable reduction in turbidity and coliform count which makes the seed powder a good source for water purification.*

*The acetone extract of seed had a strong antibacterial activity. The seed powder and its extract can control and reduce waterborne bacterial diseases (PoE8).*

Figure 23 shows crushed Moringa seeds and Figure 24 shows water that was untreated and treated (presented by Group Eight).



**Figure 23: Moringa seeds**



**Figure 24: Untreated and treated water**

### ***Water storage***

*In the past, people did not have water filters and refrigerators, water was stored in clay pots. Apart from cooling water, the alkaline clay interacts with the acidity of water and provides the proper pH balance. Water from clay pots improves metabolism and is free from harmful chemicals that are found in plastic containers (See pictures attached- Figure 25) (PoE8).*



**Figure 25: African woman carrying water in a clay pot and a Native Indian potter**

*The inclusion of indigenous practices using seeds and clay pots into the Physical Sciences curriculum was a form of action to a plan to teach the unit of work on the Hydrosphere. The use of natural resources to purify and store water identified by leveraging the indigenous practices addressed sustainability. The benefits of storing water in clay pots include keeping the water cool naturally due to the tiny air pores present in them, are affordable, save energy and are eco-friendly when compared to refrigerators, these are link to sustainable development ideologies. Water from clay pots improve metabolism because it is free from all harmful chemicals found in plastic containers (PoE8).*

Teachers did not recommend doing pottery or engaging in laborious efforts to purify water. The purpose of these ideas was to link them to science and sustainability (refer to the section on Use of Moringa seeds [Water Purification] above).

### **e. Reconstruction of unit of work**

During the micro-teaching activity, Group Eight used indigenous, narrative pedagogical strategy, namely, storytelling which included a learner activity (see Figure 26 below) related to their unit of work as a form of assessment of the content knowledge based on “Clean Water”, related IK, and the SDGs.

#### **e1. Knowledge of the ancestors**

**Example One: Curriculum Content and Activity about Water storage and purification from Africa incorporating Indigenous Knowledge:**

**LEARNER ACTIVITY:**

Read the case study below and then answer the questions that follow:

*(In the story that follows, comments and scientific observations are in brackets and italicised so that the learners can see the practical wisdom behind some water collection myths and techniques of the past).*

Before the time of the Zulu King, Shaka, sweet water was called "amanzi amnandi". Shaka's mother was called Nandi and it is said that because it was not considered respectful to use the queen mother's name in this way, Shaka referred to sweet water as "amanzi amtoti". *(This is how the town of Amanzimtoti, south of Durban, got its name)*. Today both terms are used and many people of Nguni origin will sniff, smile and hold up "sweet" water, collected from a river, spring or well for their daily household needs. *(Water quality scientists today still have people smell and taste household water. Human senses give a refined indication of whether water is good and clean and fresh).*

**QUESTIONS:**

1. Have you collected water from a nearby river? What was the water used for? (If for drinking, how were you certain that it was safe to drink?)
2. What do you think 'well oxygenated water' means?
3. Why do scientists take water samples below the surface of the water?
4. Why did the Nguni scour their clay pots regularly?
5. Name the methods that the Nguni people used to reduce the contamination of their drinking water?
6. Do you think that these practices of collecting water are still relevant today?

**Figure 26: Activity on Clean Water leveraging IK and addressing the SDGs (PoE8)**

*The micro-teaching presentation by the group was rich with indigenous terms, ideas, and practices like "amanzi amtoti", the "Nguni practice of collecting rain-water, and "clay pot storage". The above activity showed how the research, analysis, and group engagements which included those with Nkunzi allowed Group eight to "enact" leveraging IK to address the SDGs were realized. This process culminated in an actual presentation which was observed by the researcher of how the unit of work would be taught in a classroom setting (PoE8).*

***At this point of the presentation, Group Eight focused on SDGs which are linked to Water Purification***

**e2. Achieving SDGs****Example Two: Explanation of the importance of SD using IK**

Group Eight was able to identify a few SDGs which related to the action stage of the decolonial processes through using IK. This was explained during their micro-teaching presentation:

*Sustainable development Goal 6 suggests clean freshwater is an essential ingredient for a healthy human life however access to clean water and sanitation remains a major challenge for both rural and urban Africans. By linking the practice of water purification using Moringa seeds the teacher group highlighted the importance of “Clean Water and Sanitation” (SDG 6). Learners will be taught that when people get sick from consuming contaminated water, it interferes with the aims of SDG 3 which relates to promoting good health for every citizen of the world. Therefore, people must be educated about other alternatives for water treatments that could be achieved at home, as well as alternative ways for water storage that promote good health (PoE8).*

Further discussions of the enacted curriculum topic using a decolonial lens from Group Eight’s micro-teaching presentation are discussed in (i) Micro-teaching Observations: Physical Sciences unit of work on Grade 10: Hydrosphere (Appendix A2).

Next, I discuss Group One’s enactment of the curriculum using the same 8 categories as I had done for Group Eight (a. Deconstruction of a unit of work in the curriculum by Group; b. Group’s Critical analysis of textbook materials; c. Teacher learning from IK holder; d. Teacher learning from self-directed research; e. Reconstruction of unit of work; e1. Knowledge of the ancestors with associated examples of decolonised activities that groups presented; e2. Achieving SDGs)

**(ii) Example from the Life Sciences Curriculum**

**Table 7**

**Summary of Micro-teaching Presentation Group One: Life Sciences**

<b>Grade Unit of work</b>	<b>IK content</b>	<b>Indigenous Pedagogy</b>	<b>SDGs</b>
Cellular Respiration: Grade 11	a. Fermentation: umqombothi and Kefir b. the role of heat energy from the sun. c. Indigenous agricultural practices (Which include crop rotation and inter/mixed cropping).	Invitation of an IK holder into the classroom. Narration as a pedagogy.	SDG 1: No Poverty. SDG 15: Life on land.

(Source: OS1)

**a. Deconstruction of a unit of work in the curriculum by Group One**

Group One critically analysed the unit of work on “Cellular Respiration” from the Life Sciences (LS) CAPS.

<p><b>Total</b> 7½ weeks (34 hours)</p>		<ul style="list-style-type: none"> <li>- <b>Anaerobic respiration:</b> production of lactic acid in muscles during exercise; words and symbols (<i>no biochemical detail of process is required</i>);</li> <li>- The role of anaerobic respiration in the industry, e.g beer brewing and bread making.</li> </ul> <p>A <b>comparison</b> between aerobic respiration and anaerobic respiration in terms of raw materials required, products and relative amounts of energy released.</p>	<ul style="list-style-type: none"> <li>- provide relevant data that can be interpreted by learners. Identify variables, suggest controls for variables and record observations</li> </ul>
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**Figure 27: Extract LS CAPS document on Cellular respiration (DBE, 2011, p. 45) (PoE1)**

The group identified that only:

*Hans Adolf Kreb was attributed with identifying the citric acid cycle. That biochemical detail and the use of chemical exclusively without other forms of knowledge or ideologies are based on colonial ideology (PoE1).*

Group One’s analysis underscored the focus on anaerobic respiration and industrial products. The group identified the marginalization of African indigenous practices that make use of anaerobic biochemical pathways like making “steam bread” or umqombothi.

**b. Critical analysis of textbook materials (Group One)**

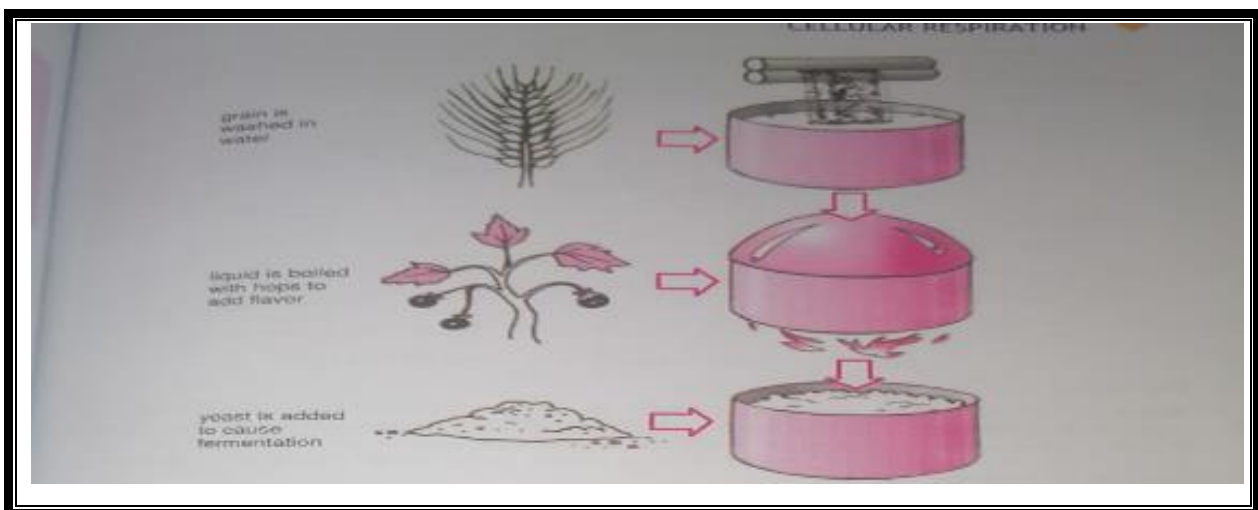
Lee, Gift, Shabba, and Imbokodo (IK holder) identified Euro-Western biases in the Oxford Successful Grade 11 LS (Bezuidenhout et al., 2012) textbook:

*In the textbook, examples of the making of red wine are Western practices. According to history, the fermentation of wine began in Georgia and Sicily. Western scientists and contexts are foregrounded. Fermentation and cellular respiration are explained in the context of Euro-Western technologies. Fermentation of red wine in an industrialised manner is a Western practice and this unit does not incorporate African IK. PoE1.*

Observation of their micro-teaching activity revealed the following insights by Group One:

Energy expensive techniques in Western beer/wine making processes are highlighted. The wine industry at large perpetuates climate change. Wine is stored in wooden barrels which are made from cut down trees which negatively affects biodiversity and oxygen yield. The wine is transported using fuel-powered, carbon emitting vehicles, stored in chemically infused glass and plastic packets in boxes, and plastic is not biodegradable. Packaging materials and cost of transport and storage make commercially produced beer more expensive and require more raw materials. In the production of “umqombothi”, only a small amount of the beverage is produced at a time for a specific traditional ceremony. It is stored and consumed in a “Calabash” which is made from the hard shell of a fruit from the gourd family “*Langenaria siceraria*”. The indigenous fermentation of “umqombothi” is a more sustainable process of beer making that learners can be taught. (OS1)

In their PoE, Group One included the following diagrams that are used to explain the process of Fermentation in textbooks used to teach the unit of work in SA schools. Figure 28 shows the extract from the Oxford Successful Life Sciences Grade 11 textbook.



**Figure 28: Extract from Grade 11 textbook explaining the Fermentation process used to teach Cellular respiration (PoE1)**

### c. Teacher learning from IK holder:

Indigenous content related to the fermentation process of “umqombothi” and discussions on African festival rituals such as initiation school graduations, celebrations, communication with ancestors (Amadlozi). Umqombothi is vital for social and spiritual relationships. Invite ancestral spirits to participate in milestone activities. Connects spirits of the ancestors with those of the living. Labour intensive grain is crushed by women using “Idwala” which is another Isizulu word for “rock”. Women are involved entirely in the process and are respected as the authority in preparing umqombothi. Female gender has a key role in linking ancestral spirits to present ones. This links the SDG 5: Gender equality wherebv men are not the only gender to offer wisdom and spiritual guidance to the family. PoE1.

The connection of human beings to the earth emanates from using the “grinding rock” to crush naturally extracted ingredients. The connectedness with nature by using sunlight and not a stove or fire for heat was also identified. Indigenous groups work collaboratively and use sunlight to heat the mixture to make umqombothi organically and not use fuel that emits harmful carbon dioxide. This demonstrates the *ubuntu* ideology where human-human-nature connections are valued.

### d. Teacher learning from self-directed research

In their portfolio of evidence (PoE1), teachers included the following:

We began research by conducting in-depth literature search about the fermentation in the making of “Sorghum beer” which was localised and relatable to what SA learners were familiar with. We referred to articles such as “Hlangwani, E., Adebisi, J. A., Doorsamy, W., & Adebo, O. A. 2020. Processing, characteristics and composition of umqombothi (a South African traditional beer). *Processes*, 8(11). 1451”. We watched many YouTube videos about SDGs and IK in beer production. PoE1.

Another example of indigenous fermentation is “Kefir” which originated in Eastern Europe, the group also researched this:

Kefir is an acidic-alcoholic fermented milk product with little acidic taste and creamy consistency that was originated in the Balkans, in Eastern Europe, and in the Caucasus. Kefir grains are added to goat or cow’s milk. Over approximately 24 hours, the microorganisms in the kefir grains multiply and ferment the sugars in the milk, turning it into kefir. The bacteria ferment the lactose in milk to lactic acid and provide the tangy flavour, while the yeasts ferment the available fermentable sugars in milk to yield small amounts of alcohol and CO<sub>2</sub>, which gives kefir its fizz and effervescence.

PoE1.

The examples presented by Group One of firstly umqombothi (African), and secondly Kefir (Eastern European) explore the intercultural indigenous dialogue while focusing on concepts from the science curriculum.

## **e. Reconstruction of unit of work**

### **e1. Knowledge of the ancestors**

During Group One's micro-teaching activity, they used the indigenous, narrative pedagogical strategy, of storytelling. Below is an extract taken from the group's observation schedule:

**Storytelling pedagogy:** The teachers in Group 1 were told a story by “Imbokodo” which they role-modelled during the micro-teaching presentation. The story began with the traditional significance of “umqombothi”. It features at Zulu and Xhosa weddings, funerals, rites of passage, and imbizos (traditional meetings). It's also a customary part of making contact with the ancestors. In addition to the story of umqombothi, Imbokodo also indicated that umqombothi has a lower alcohol content than most commercially bottled beers. In traditional African culture, umqombothi is associated with respect for customs and traditions and not with intoxication. Drinking umqombothi from the gourd calabash which represents the cosmic womb. Inside it, the umqombothi directs intentions to “birth to life”, showing the strong links between African people and the cosmos. For example, drinking it at a Zulu wedding invites the positive intervention and sustainability of the marriage by the ancestors. The group further modelled the Ubuntu-ism shown by the consumption of umqombothi in a communal setting. The literal sharing of the traditional beverage between people sitting within a circle drinking from a single calabash emphasises the circle of life and the connectedness of human to human, human to nature and human to the cosmos.  
(OS1)

Various dimensions of connectedness are represented by indigenous and cultural practices that encourage relationships between people and people, and between people and the natural world.



**Figure 29: African Calabash (Source: PoE1)**



**Figure 30: The Cosmic Womb (Source: PoE1)**

Below I present two examples of African-centric curriculum materials developed and presented by Group One during the micro-teaching activity.

## Example One: Curriculum Content about Alcoholic Fermentation from Africa

The role of anaerobic respiration, e.g., making of umqombothi. On the topic of Cellular Respiration, the fermentation of sorghum beer can be used as an example to enable learners to develop a deeper understanding of the concept. Sorghum beer (umqombothi) is an alcoholic beverage obtained from the fermentation of sugars, mainly those obtained from barley malt. This example from African culture can be taught to learners.



**Step one:** Mix half the malt with the maize meal in a bowl. Place the bowl in direct sunlight and add 2 litres of water and stir until you have a smooth paste.  
*What is in the malt? Why is this important?  
Why is sunlight important?*



**Step two:** Set aside in the sun, cover with a lid and leave in a warm place overnight to begin fermenting. Pour 4 litres of water into a large pot. Work in the soured mixture, stirring constantly.



**Step three:** Add 6 litres of cold water, mix in the remaining King Korn Mtombo and brown sugar. Cover with a lid and set aside for between 2 and 3 days to ferment. On the third day the fermented mixture will have a pungent smell and tiny bubbles will appear on the surface.  
*What type of fermentation has occurred? What type of gas is present in the bubbles? Write a word equation to show the reaction*

Pour the beer into a large fine-mesh sieve. Using your hand or a large wooden spoon, press the beer mixture through the sieve to achieve a smooth liquid. At this point the teacher can discuss cellular respiration through the fermentation process. Evidence from the pungent smell and tiny bubbles in the "umqombothi", indicate the release of gases (POE1).

*Activity: Curriculum Content inclusive of African and Euro-Western science*

The activity presented in Group 1's POE was teaching of the "Law of the Conservation of Energy" using the Fermentation process. The law states that "the number of atoms in the reactants is equal to the number of atoms in the products" taken from the Oxford Successful Life sciences Grade 11 textbook (Bezuidenhout et al. 2012, p. 102).

*Word equation for fermentation:*

**Sugar (glucose) + yeast → ethanol (alcohol) + carbon dioxide**

Learners are required to:

- Identify the reactants and the products in the above word equation.
- Write out the chemical equation for Alcoholic Fermentation.
- Balance the chemical equation for Alcoholic Fermentation.

Figure 31: Umqombothi making process and Associated Learner Activity (PoE1)

**Group One’s micro-teaching activity then focused on SDGs which are linked to alcohol production from fermentation:**

The production of “umqombothi” is more environmentally friendly compared to the industrial process of western beer/wine-making. The indigenous ways of creating the sorghum beer by asking local indigenous people to make and sell it contributes to addressing poverty in the local communities. This addresses SDG 1: No poverty. The selling of “umqombothi” and “kefir” becomes a source of income which indigenous people can use to provide for their families. SDG 15: Life on land was also addressed. Indigenous people place the ingredients to make umqombothi in the sun (Figure 4), the heat energy accelerates the rate of reaction and fermentation. Heating ingredients using the sun as opposed to using industrial convection ovens or kettles in beer/wine-making means there will be less carbon emissions harming the planet. Traditionally, kefir grains were cultivated and extracted sustainably, by not overharvesting. Sorghum and maize, used in the production of umqombothi were traditionally grown using sustainable indigenous methods, including crop rotation and intercropping. (POE1)

**e2. Achieving SDGs**

Group One presented the second activity in their PoE which focused on SDGs and IK.

**Example Two: Learner Activity about Fermentation and Traditional beer proposed by Group One:**

Read the information below and answer the questions that follow.

**Traditional African Beer**

Traditional beer forms a very important part of African culture. It is called *umqombothi* in isiXhosa and *iJuba* in isiZulu. The beer is mostly brewed from indigenous sorghum. The thick creamy African beer is very rich in vitamin B, it has a low alcohol content of less than 3% and it is inexpensive. The recipe for brewing beer is passed down through the generations.

The traditional method of testing to see if the brew is ready is to light a match close to the container of beer. If the flame dies quickly, the brew is ready. If the flames remain lit, the brew is not ready.

- 2.2.1 Name the biochemical process used to brew this African beer. (1)
- 2.2.2 What causes the flame to die? (1)
- 2.2.3 Why would this test be an indication of whether the brew is ready or not? (2)

A survey was done to determine the amount of people who drink industrially produced beer and traditional beer. The results for 1970 and then 1996 were as follows:

Type of beer	Percentage of beer consumed	
	1970	1996
Traditional beer	90%	30%
Industrially produced beer	10%	70%

- 2.2.4 Plot a bar graph to show the results of the survey. (6)
  - 2.2.5 Describe the trend shown by the graph. (2)
- (12)

**Figure 32: Science about Cellular respiration using an example from Africa (PoE1)**

The two examples presented above assisted in reconstructing the unit of work without compromising the development of scientific competencies such as “biochemical processes and data presentations (graphs)”. Activities were developed to deepen the understanding of sustainability, Euro-Western practices and science, and indigenous knowledge. Group One decolonised this unit of work by focusing on indigenous examples and content that permeated Euro-Western teaching pedagogies and strategies which was not sparse and superficial (as discussed in section 5.3.1).

Further discussions of the teaching using a decolonial lens by Group One are discussed in (ii) Micro-teaching Observations: Life Sciences unit of work on Grade 11: Cellular respiration (Appendix A2).

***(iii) Example from the Natural Sciences Curriculum***

**Table 8**

***Summary of Micro-teaching presentation Group Five – Natural Sciences***

<b>Grade and Unit of work</b>	<b>IK content</b>	<b>Indigenous Pedagogy</b>	<b>SDGs</b>
Grade 6: Inorganic Fertilizers	Indigenous agricultural techniques: Including Soil nutrient retention. Using chicken waste and cow dung.	Group work; Debates on the subject of Indigenous communities.	SDG 6: Clean water and sanitation. SDG 15: Life on land.

**a. Deconstruction of a unit of work in the curriculum**

Group Five made up of three members, Essy, Sbu, and Amandla (IK holder) critically analysed the Grade 6 Natural Sciences unit of work “Water Pollution and Inorganic fertilizers” in the CAPS document. Inorganic Fertilizers as a topic should be taught about water pollution through “reading about water pollution” and viewing “video clips from the internet” as specified on page 55 of the CAPS document shown in Figure 33.

GRADE 6 TERM 2				
STRANDS: NATURAL SCIENCES: MATTER & MATERIALS TECHNOLOGY: PROCESSING				Equipment and Resources
Time	Topic	Content & Concepts	Suggested Activities: Investigations, practical work, and demonstrations	
	Mixtures and water resources	<p><b>Water pollution</b></p> <ul style="list-style-type: none"> <li>• in the environment, many things mix or dissolve in water</li> <li>• water can be polluted by               <ul style="list-style-type: none"> <li>- insoluble substances, such as oil, plastics, tyres, tins, glass, toilet waste</li> <li>- soluble substances such as soaps, fertilizers, insecticides, acids and other poisons</li> </ul> </li> </ul>		<ul style="list-style-type: none"> <li>• Texts for reading about water pollution</li> <li>• Video clips from the internet</li> </ul>

**Figure 33: Extract from Natural Sciences CAPS document on Water Pollution (DBE, 2011, p. 55) (PoE5)**

The group indicated that “synthetic fertilizers, soaps, chemical insecticides, and other poisons are products of Euro-Western chemistry and are harmful to the lithosphere, hydrosphere, and atmosphere” (PoE5).

**b. Group Five engaged in Critical Analysis of textbook materials**

The group examined the prescribed “Oxford Natural Sciences Grade 6 textbook” to inform the unit of work on Fertilizers. Figure 34 captures an extract from the textbook, and is followed by the group’s critique thereof, which was included in PoE5:



All fertilizers have three numbers on the label, which indicate the fertilizer analysis, or "percentage by weight" of **nitrogen, phosphate ( $P_2O_5$ ) and potash ( $K_2O$ )**, always in that order. In the picture to the left, the bag of lawn fertilizer has 25% nitrogen (N), 5% phosphate, and 5% potash. P is the symbol for the element phosphorous, and K is the symbol for the element potassium, and O is the symbol for the element oxygen.

**Figure 34: Extract from Oxford Natural Sciences Grade 6 textbook on fertilizers (PoE5)**

Artificial chemical fertilizers contain hazardous chemicals in addition to NPK which include, zinc, lead, cadmium, chromium and even arsenic. These chemicals may result in harmful effects to animal, human and environmental health. The use of these fertilizers contributes to unsustainable [practices], and these have come from colonial agricultural practice. Indigenous agriculture offers sustainable ideas about different products and methods to enhance soil nutrient content and retention PoE5.

The use of these fertilizers contributes to unsustainable, colonial agricultural practices, which are different from what indigenous forms of fertilizers and sustainability motivate for. Using CDA, Group Five was able to:

*(...) screen traces or elements of colonialism interrogating the examples, pictures, context, cultural tools, teaching resources used, and origin of authors (Van Dijk, 2015). We looked at the names of the authors for Oxford Natural Sciences and these names are not African names but European names, like “F Baxter and M Viljoen” (PoE5).*

Govender and Mudzamiri (2022) emphasized the importance of incorporating indigenous artefacts in developing an integrated indigenous-pedagogical model in the curriculum. I captured teacher learning from my observation of the micro-teaching presentation by Group Five, using the Observation Schedule (OS) and teacher reflections from the PoE.

### **c. Teacher learning from self-directed research**

The following was captured from PoE5 which indicated the reflections from teachers about their knowledge of natural fertilizers used by indigenous people:

*Chicken manure adds organic matter and increases the water holding capacity and beneficial biota in soil. Chicken manure provides more Nitrogen, Phosphorus and Potassium to plants compared to horse or cattle manure (Chen & Jiang, 2014).*

*Cattle manure, or cattle dung, is used in farming as a popular practice in many rural areas. This type of manure is rich in nitrogen. Composted cattle manure can provide numerous soil benefits. Cattle dung can be reused as soil amendment to serve as slow-release P fertilizer (Chen et al., 2018)*

*Chen et al. (2018) note that soil which is made nutrient-dense using natural fertilizers contains the primary plant nutrients, namely, nitrogen, phosphorus and potassium along with a host of minor nutrients that promote plant growth PoE5.*

Group Five also explored using cow dung through Indian, Ayurvedic knowledge:

*Cattle dung in India is also used as a co-product in agriculture, such as manure, biofertiliser, biopesticides, pest-repellent (through the smoke from burnt dry cattle dung), as a source of energy and for sanctifying the soil. According to Ayurveda, it can also act as a purifier for all the wastes in the nature. According to Ayurveda, Gomeya/cattle dung is not a waste product, but it is a purifier of all wastes in the nature. When spread over urban and rural waste in solution form, it biodegrades the waste in time. [Source: Gupta et al. (2016). Current status of cattle dung as a bioresource for sustainable development, Bioresources and Bioprocessing, 3(1), 1-11] PoE5.*

#### **d. Teacher learning from IK holder**

Group Five indicated learning about the usefulness and potential harm (when used in incorrect concentrations) of natural fertilizers from their IK holder, Amandla. Amandla advised them to use indigenous pedagogies like classroom debating and discussions. The IK holder also explained that debating was used by African indigenous communities for centuries during counsel and village meetings to resolve disputes and test peoples' intellect:

*Long before Africa was colonised, African societies used the institutional mechanism of “public debating” as a cultural tool to uphold the values of peace, tolerance, solidarity and respect for one another, i.e., Ubuntu. Amandla proposed that learners engage in debates about the usefulness and potential harm that can result from the use of artificial fertilizers, produced because of Euro-Western chemistry, and natural fertilizers commonly used by indigenous people (OS5).*

#### **e. Reconstruction of the unit of work from the curriculum**

Below are two examples to revise the unit of work developed by Group Five.

##### **e1. Knowledge of the ancestors**

##### **Example One: Curriculum Content about natural fertilizers**

Members of Group Five researched how indigenous people made and used fertilizers. These enrich the soil and serve the same purpose as Euro-Western examples of inorganic fertilizers presented in prescribed textbooks.

At learners' households, parents only practice subsistence farming which depends on natural fertilizers because chemical fertilizers are expensive for them. There is a common practice done in most villages, in a Rondavel (African Hut often used as kitchen and where chickens sleep), every morning indigenous people sweep chicken waste and throw the waste into the garden. Discussions of the significance of a Rondavel and chicken waste as fertilizers could be explained to learners.

**Figure 35: Chicken waste as a natural fertilizer (PoE5)**



*Another traditional practice that could be used when teaching fertilizer is the use of cattle dung when planting to enrich soil with nutrients. Indigenous people remove dried cattle dung from the kraal and mix seeds like maize with it. They add other biodegradable waste materials to the dung mixture, which is added to the soil as fertilizer.*

**Figure 36: Cattle dung used as fertilizer by indigenous people (PoE5)**

The group could include the above examples within a unit of work on inorganic fertilizers in the Natural Sciences Grade 6 curriculum which could address various SDGs. The “Chicken Waste”, and “Cow Manure” for enhancing soil fertility were indigenous examples. The IK holder verified the accuracy of the indigenous practice, related to these natural forms of fertilizer. After this verification, the information was included in PoE5 and during their micro-teaching presentation.

Group Five discussed the following SDGs which were associated with the unit of work on inorganic fertilizers.

## **e2. Achieving SDGs**

The group presented the SDGs by tapping into indigenous knowledge about fertilizers. The group specifically addressed SDG 6 (Water and Sanitation) and SDG 15 (Life on Land):

*SDG 6 was addressed whereby Euro-Western fertilizers were explained to cause poor biological condition to water resources. Lakes and rivers become “hypereutrophic” (meaning that high levels of nutrients and algae are degrading water quality). High levels of “nutrients,” such as phosphorus and nitrogen (both components of synthetic fertilizer) threaten the health and biological diversity of waterways, which can result in loss of aquatic life and their habitats, shellfish contamination and seasonal dead zones. They also cause algal blooms which harm aquatic. Excessive nutrient runoff in waterways can impact drinking water supplies and cause severe health problems.*

*CAUTION: Using Natural fertilisers recommended by IK holder- the use/disposal of chicken and cattle waste should be done in a sustainable manner and not be allowed to enter water sources through soil run off. The high ammonia content in chicken and cattle waste is harmful to aquatic creatures. When ammonia is present in water at high levels, it is difficult for aquatic organisms to sufficiently excrete the toxicant, leading to toxic build-up in internal tissues and blood, and death. Environmental factors, such as pH and temperature, can affect ammonia toxicity to aquatic animals (Chen et al., 2018) PoE5.*

This approach where SDG 6 was addressed in the context of both indigenous and Euro-Western knowledge marks a decentring of Western knowledge and the production of that “third space” (Le Grange, 2016, p. 10) in which different knowledges can function together to create an accountable curriculum (according to Mudaly, 2018a).

*Links to SDG 15, the protection of Life on land by using organic fertilizers. Organic fertilizers, when used correctly, cause less damage to the environment than inorganic fertilizers. Inorganic fertilizers are toxic to soil organisms, they poison the soil organisms and enter and are passed along the food chain causing harm to all feeders, thereby threatening life on land. Organic fertilizers when applied correctly using the indigenous methods enhance soil nutrient retention. Manufacture, storage and transport costs of inorganic fertilizers surpasses that of organic fertilizers. (Chen & Jiang, 2014) PoE1.*

### **Example Two: Practical Activity to develop skills related to improving soil nutrient content using indigenous knowledge**

*In the micro-teaching session Essy presented details of how Group Five developed and implemented a practical activity based on different forms of soil nutrient retention techniques. Essy and Amandla had transported learners to Amandla's domestic garden. Amandla demonstrated to the learners the preparation techniques for traditional fertilisers for her garden using cattle dung and chicken waste. Learners engaged in hands-on activities, by following Amandla's instructions related to the soil turning technique, whereby only the soil needed for planting was turned using garden forks and spades. Essy explained to learners that these techniques are different from industrial techniques, where large plots of land are turned using industrial machines which give off high yields of carbon-dioxide and disrupt subterranean biomes. Learners were given an opportunity to mix in the animal waste with other biodegradable materials like vegetable peelings and prepare beds for planting (OS5).*

Further discussions of Group Five's micro-teaching presentation are presented in (iii) Micro-teaching Observations: Natural Sciences unit of work on Grade 6: Inorganic Fertilizers (Appendix A2).

Next, I discuss Group Two’s enactment of the curriculum.

**(iv) Example from the Mathematics Curriculum**

**Table 9**

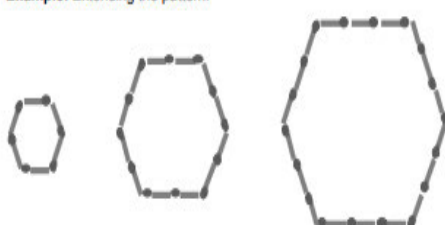
**Summary of Micro-teaching Presentation by Group Two: Mathematics**

Grade & Unit of work selected	IK content included	Elements of Indigenous pedagogy to be included	SDGs to be addressed
Grade 6: Geometric patterns	Zulu patterns and Beadwork explain the significance in terms of the isiZulu culture.	Playing/ practical work using beadwork. Planning to involve an IK holder to narrate cultural significance.	SDG 1: No poverty. SDG 2: Zero hunger. SDG 15: Life on land.

(Source: OS2)

**a. Deconstruction of a unit of work in the curriculum by Group Two**

Group Two, comprising four teachers, Will, Precious, Josh, and Umdwebi (IK holder) critically analysed the Grade 6 mathematics curriculum based on Geometric patterns under the topic “Patterns, Functions, and Algebra”. Figure 37 below shows page 249 of the Intermediate Phase Mathematics CAPS document where the unit of work is located. Geometric patterns are taught in the context of ratios and number patterns.

CONTENT AREA	TOPICS	CONCEPTS AND SKILLS	SOME CLARIFICATION NOTES OR TEACHING GUIDELINES	DURATION (in hours)
PATTERNS, FUNCTIONS AND ALGEBRA	2.2 Geometric patterns		<p>Example: Extending the pattern:</p>  <p>Describing the pattern in own words            "It is a pattern of hexagons"            "Each hexagon is bigger than the one before"</p>	6 hours

**Figure 37: Extract from Mathematics Grade 6 CAPS document (DBE, 2011, p. 249) (PoE2)**

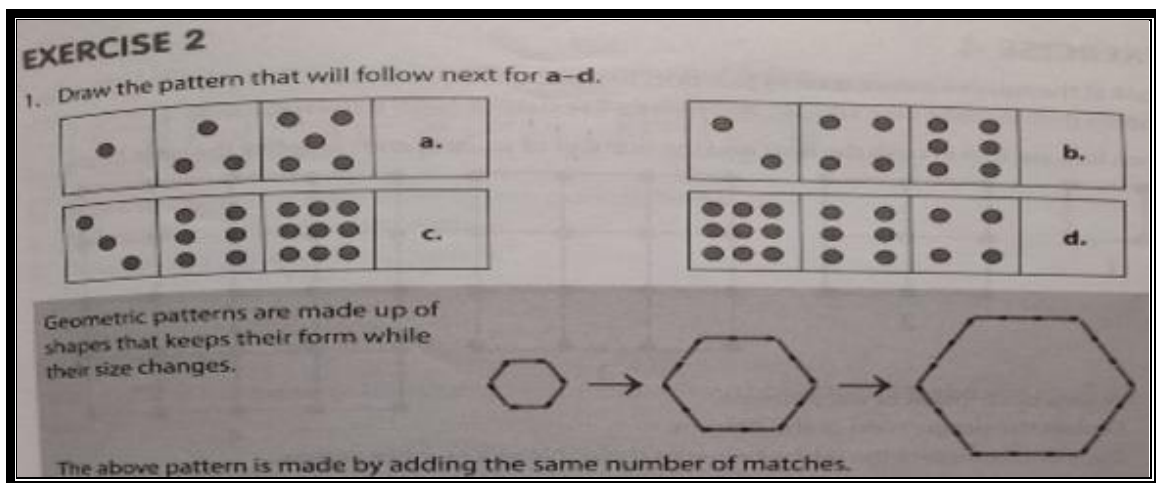
The reference to materials such as “matchsticks” to develop shapes like “Hexagons” within the CAPS document were examples used to teach geometric patterns (PoE2). These were linked to colonial, Euro-Western underpinnings persistent in the mathematics curriculum (Raju, 2017), which the group identified.

**b. Group Eight engaged in critical analysis of textbook materials**

Group Two through CDA identified that:

*Textbooks convey the topic as something irrelevant and abstract, the questions are not culturally relevant. The textbooks used dice and match sticks as examples. From a total of 18 authors of the three textbooks reviewed, 17 were Euro-Westerners”. Shapes like Hexagons were often linked to Euro-Western structures and were abstract from the context of African learners. The group noted that “only one out of three prescribed textbooks included African indigenous knowledge, and it was only used for one question”. They noted that the textbooks showed shapes of urban houses which many disadvantaged SA learners may not always relate to, especially in rural contexts (PoE2).*

Figure 38 captures an extract from a textbook on the unit of work on Geometric patterns that Group Two analysed.



**Figure 38: Extract from the textbook used to teach Geometric patterns (PoE2)**

*The textbook refers to playing “Die” which can be used to teach the unit of work because it can be arranged into patterns when playing games*

*like “Dominoes” and other Western-infused games. These examples of shapes and Geometric patterns formed the basis of what Group two looked at when trying to decolonise the unit of work. The use of chemical-infused matchsticks and die, made from environmentally harmful thermoset plastic made in industrial-western machines which emit harmful gases which contribute to an unsustainable practice, different from what the use of indigenous beadwork (made from recycled materials) and sustainability motivates for (PoE2).*

### **c. Teacher learning from IK holder**

Group Two in their micro-teaching session presented information they learnt from Umdwebi, the IK holder, which they included in their PoE:

*Traditional Zulu beadwork was used together with the contemporary examples present in the textbook and the CAPS document. Used African beaded jewellery to describe geometric patterns and identify shapes in the patterns. We motivate for the use of African beads which were historically seeds, shells, or beads created from natural fibres and painted using brightly coloured soil or debris. However, we will make learners aware that there are people who use beads made from recycled glass and plastic. Learners will also learn about a local Artisan’s history. Zulu beadwork is not only beautiful but also rich in tradition and cultural meaning. Beadwork is practiced by Zulu women who take ownership for these powerful skills and knowledge by passing it down through generations to younger women (PoE2).*

The group through their engagements with their IK holder said that seeds, shells, and bags made from rope-like natural fibres were also historically used (OS2).

### **d. Teacher learning from self-directed research**

In terms of examples of patterns, the group sought to move away from “Matchsticks and Die” and focus more on Zulu patterns and Beadwork which they retrieved from engaging in active research. These are shown below in Figure 39.



**Figure 39: African Beadwork to be used to teach Geometric patterns in Grade 6 (PoE2)**

The group noted that the Zulu patterns and beadwork significance in terms of the isiZulu culture will be explained to learners. Patterns related to respect for the ancestors, whereas coloured beads symbolize important cultural messages like virginity (white beads) and growth (green beads) (Collett, P., & Steyn, C. (July). Using African Designs in Virtual Manipulatives for Geometrical Concept Development. In *Proceedings of Bridges 2017: Mathematics, Art, Music, Architecture, Education, Culture*, 455-458) (PoE2).

Group Two endeavoured to address the pedagogy in the unit of work. They experimented with the idea of play as a form of indigenous pedagogy as identified by Mudaly (2018b). The teacher group planned to put learners in groups to play using the games (like Mlaba-laba) which make use of Geometric patterns and to apply this learning during classroom activities:

*The pedagogy and teaching approach also resembled decolonial thinking and a focus on Ubuntu. Learners are to be seated in groups of 4. Group work will facilitate active learning and encourage learners to communicate more confidently and freely. Group learning according to Umdwebi, the IK holder we consulted, is valued in Indigenous African Knowledge (PoE2).*

## **e. Reconstruction of unit of work**

### **e1. Knowledge of the ancestors**

The following information was presented and discussed during the group's micro-teaching session:

*It is also known that, in addition to being an indicator of a person's wealth, beadwork was also used to help identify the region from which a person came and their marital status, help diviners (isangoma, pl. izangoma) perform divination rites, and encourage conformity to accepted behaviour between courting and engaged young men and women. Beadwork has continued to be an important link between the body and ancestors. Beadworks are symbolic expressions among Zulu-speaking people in the twentieth century - used to express various aspects of identity (Boram-Hays, C. (2018). Between the body and the ancestors: expressions of religious thought in the clothing of Zulu-speaking women in the Nongoma region of KwaZulu- Natal, South Africa. Southern African Humanities, 31(1), 31-54) (PoE2).*

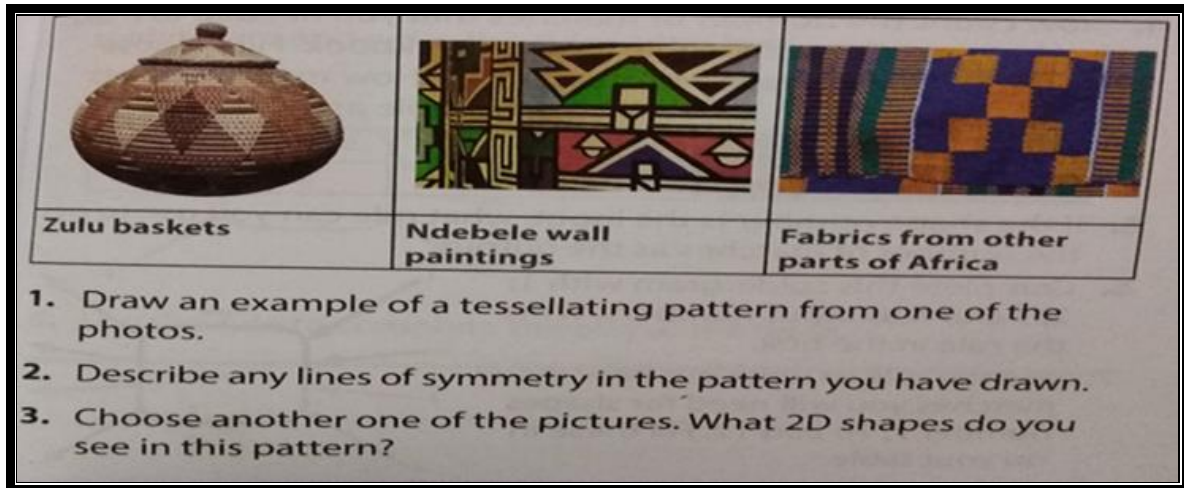
The teaching of geometric patterns using indigenous examples contributes to a holistic approach to teaching. African learners will value their own identity through learning in this way. Soyinka (2021, 72) notes that:

Symbolic geometric patterns can represent cultural beliefs and history. There is a lot of meaning in the way the patterns are arranged and they often represent the wisdom of a tribe for example. They can act as a record of the events and daily activities of that tribe. Common patterns include parallel zigzags which are used to remind the artist and the user that the path in life is never straightforward but is often difficult to travel. On the African continent, various tribes apply motifs to fabric, pottery, and paper that have symbolic significance and tell a story.

Teaching in this way can help deepen the understanding of geometry making it more relevant to the values and attitudes that indigenous people hold.

### **Example One: Curriculum Content about African Beadwork and Geometric Patterns**

Group Two included a learner activity that encapsulated IK ideologies and addressed SDGs (Figure 40). A discussion on the patterns served as an introduction to the activity, this is where the IK and the SDGs were addressed.



**Figure 40: IK-linked Geometric patterns to address SDGs (PoE2)**

These ideas and proposed activities to teach the unit of work were presented by Group Two and observed by the researcher. The sustainability issues are addressed through discussions of the pictures, how they are produced sustainably and how they are sold.

**Example Two: Practical activity using African Beadwork:**

*The group was also able to fuse pedagogy and the indigenous content that they leveraged to address SDGs. From my observation of their micro-teaching presentation, Group Two planned to address the SDGs by requesting Umdwebi to bring in beadwork to the lessons for learners to play with, while the IK holder narrated stories of the significance of the colours and patterns. This story-telling was a form of indigenous pedagogy presented by the group. Learners would then be required to identify and draw geometric patterns that they observed from playing with the African beadwork (OS2).*

**e2. Achieving SDGs**

Group Two identified the following SDGs that they could address by leveraging IK within their selected unit of work: SDG 1: No poverty, SDG 2: Zero Hunger, and SDG 15: Life on land. Below is an extract from Group Two's PoE:

*Indigenous Ndebele wall paintings and fabrics are part of artwork done by people of Africa for commercial and decoration purposes. The*

*geometric patterns consist of a series of shapes. These shapes can be squares, circles, rectangles, ovals, triangles, pentagons, octagons, and diamonds (as visible in both Figure 38 of the western examples and Figure 39 of the African indigenous beadwork examples). Patterns made from shapes are similar to patterns made from numbers because the pattern is determined by a rule. Learners can be taught that local community members can sell beadwork to tourists and make a living and provide food for their families. This addresses SDGs 1 and 2.*

*SDG 15: Materials used in beadwork and mats can be natural seeds or recycled materials (that would otherwise be disposed of in landfills) used responsibly to benefit human beings while caring for the land. This is different to using factory produced synthetic materials for mats or glass beads. African countries produce recycled glass beads each year to support a growing economy. All production is done by hand, using recycled elements from former glass waste, such as bottles, vases and containers. The process is entirely manual, from the grinding of the beads to a fine grain; to the firing process within a kiln, that does not emit toxic waste from machines as even fuel is natural and used sparingly.*

*Although recycled powder-glass beads (such as the spectrum of varieties here at The Bead Chest) are by far the most widely produced and sought after; there is an altogether different kind of recycling utilized for bead-making in Uganda (Kaschula, 2017). African beads are not all of the recycled glass variety and learners should be taught about how to care for the land by using the recycled or natural forms (PoE2).*

Further discussions of the teaching of the curriculum topic by Group Two are presented in (iv) Micro-teaching Observations: Mathematics unit of work on Grade 6: Geometric patterns (Appendix A2).

### **5.4.3 Theme Three: Teachers enacted *Ubuntu-currere***

Teachers drew on ideologies from *Ubuntu-currere* as purported by Le Grange (2019) and discussed by Hlatshwayo et al. (2020) as a strategy to address the SDGs by leveraging IK. *Ubuntu* is an inherent ideology within African people (Molefe, 2016), and was enacted through the democratic

unification of different people through social interactions. The *Ubuntu-currere* was enacted through epistemological unification through Euro-Western infused curriculum content knowledge, indigenous knowledge, and sustainable development knowledge in a democratic, respectful and representative manner. The purpose of adopting *Ubuntu-currere* was for teachers to collaborate and challenge the “epistemic othering” of IK in the curriculum.

Responses from teachers to questions from FGI2 revealed that decolonising units of work through social interactions such as collaboration and collective engagement as well as challenging epistemic othering by leveraging IK was used to address the SDGs.

#### **5.4.3.1 *Ubuntu-currere*: Collaborative Engagement**

Social interactions are a catalyst for reinvention and critical thinking (Bernier, 2018), and form the basis for the African *ubuntu* paradigm (Takyi-Amoako & Assié-Lumumba, 2018). The dimension of *Ubuntu-currere* through collaboration was noted in Sbu’s response to Question 6 of FGI2. The question read as follows, “Is it difficult to address the Sustainable Development Goals through the science and/or mathematics curriculum? Explain”. Sbu said:

*I was the one most struggling in that module regarding the SDGs. (Only) until we had the first focus group discussion (did) it become clear. The focus group interviews assisted us so then I was able to start writing (Q6-FGI2).*

The “focus group discussions” that Sbu was referring to were FGIs. Sbu stated that the FGIs “assisted” him to start writing and reporting on IK and SDGs which demonstrated social interactions and intellectual collaboration among teachers involved in each FGI.

The camaraderie between teachers served as a support mechanism, which in Sbu’s view was imperative to complete the decolonisation of the unit of work. Question 9 of FGI2 which required teachers to share their experiences of working within a group to complete the micro-teaching task expanded on the importance of collaboration. Dwayne noted that:

*It was a pleasant and positive experience (...). It also provided me with insight into practices I was previously not exposed to which enriched my understanding (FGI2-Q9).*

Dwayne shared similar views to Sbu in that, working with other teachers through collaboration was a strategy that could be used to leverage IK to address SDGs in the science and mathematics curriculum. He used the terms “positive experience” and “enriched my understanding”. The IK holders that the teacher groups engaged with were well-known, respected, and valued for their work in the community. For example, the artisan which whom Precious from Group Eight engaged was known by the local school community and recommended to the group by Precious’ mother. This shows the good standing that the artisan had in the community. Group One worked with an IK holder who was the “producer of umqombothi in the community and everyone came to her for their ceremonial needs” as was documented in Group One’s PoE (Figure 31 and Chapter Four above).

Sbu, in responding to Question 9 of FGI2 about experiences of working within a group, emphasised the contribution of the IK holder as follows:

*Most people around this area live with it (...), so, they do these things of “Imbiza”, they do this thing “Ukumba”. Like even the beadwork, so it was really interesting to get some of the ideas from those people (FGI2-Q9).*

By consulting IK holders and experiencing the culture and traditions through the artwork of people, Sbu was able to engage with IK and the SDGs in the module. Sbu noted that science and mathematics teachers can work with IK holders to re-center IK in the curriculum.

Sbu’s experiences of working with the IK holder were supported by Dwayne in his response to Question 10 of FGI2, where he was asked “How were your experiences working with the indigenous knowledge holder? Did you obtain any insights related to leveraging indigenous knowledge to address the Sustainable Development Goals? Please explain”. Dwayne said:

*the indigenous knowledge holder provided my partners and I with insightful knowledge into practices that were passed on through generations. Through engaging with the indigenous knowledge holder, we also worked within a Sustainable Development Goal which resonated with partnerships for change (FGI2-Q10).*

Dwayne and his “partners” (members of his group) consulted the IK holder and were able to create a blended community of teachers and an IK holder which assisted with the process of decolonising the curriculum to address SD.

### 5.4.3.2 *Ubuntu-currere*: Challenging epistemic othering of IK

Another strategy that science and mathematics teachers adopted that related to the *Ubuntu-currere* was challenging the “epistemic othering” of IK. Euro-Western concepts present in the science and mathematics curriculum, together with IK and SDGs which were selected by teachers created a “third space” (Le Grange ...) where IK could no longer be ignored in the curriculum.

#### Evidence from Focus Group Interviews

The teachers in their responses to questions from FGI2 explained that by challenging epistemic othering in the curriculum, they were able to leverage IK to address the SDGs. Epistemic othering of IK according to Keet (2014, p. 24) “constitutes epistemic injustice, which is inscribed in the disciplinary formations of knowledge. As they help us produce our world, these formations, nowadays, preside over a considerable part of university practices and their conditions of privilege and disadvantage”. The concept of challenging the notion of epistemic othering of IK as discussed in Chapter Three guided this assertion.

Precious, for example, spoke about how IK holders contributed indigenous and cultural examples to her planning of the unit of work on geometric patterns. Responding to question ten of FGI2, “What were your experiences working with the indigenous knowledge holder?” She stated:

*For my task, I focused on traditional Zulu beadwork. Then, I approached an artisan to talk to him (FGI2-Q10).*

Precious shifted both her view on the source of epistemology (African IK holders as opposed to frameworks developed by Euro-Westerners) and the resources used to teach geometric patterns (African beadwork as opposed to Die or matchsticks).

Hlatshwayo et al. (2020) in challenging epistemic othering of IK, suggest that enacting an *Ubuntu-currere* in higher education does not reject (existing Euro-Western) knowledge systems but calls for epistemological diversity in curricula. Teacher participant Dwayne endorsed Hlatshwayo et al.’s (2020) sentiments when responding to FGI2, Question seven. The question read as follows, “What challenges do teachers encounter when working with addressing Sustainable development Goals in the school curriculum before you engaged with the Curriculum Development module?”. He stated:

*I believe teachers are firstly unaware of the SDGs and the methods through which they can be integrated into their teaching practices. Furthermore, once teachers are made aware of such knowledge of the SDGs, they would then need to have knowledge of strategies to (incorporate) SDGs in their lessons (FGI2-Q7).*

Dwayne explained that a challenge was that “teachers are (...) unaware of the SDGs and the methods through which they can be integrated into their teaching practices”. By exposing teachers to working with a diversity of knowledge and ideologies in the science and mathematics Honours module, Dwayne was able to obtain “knowledge of (inclusive) strategies” which he and his teacher group used to plan and present Life Sciences content knowledge, IK, and knowledge of the SDGs in a single unit of work as shown in Table 7.

Challenging epistemic othering came to be enacted in a PD moment where teachers were asked to leverage IK to address the SDGs within a unit of work from the school curriculum. They were asked, “Can indigenous knowledge be leveraged to address the Sustainable Development Goals within the science and/or mathematics curriculum?” (FGI2-Q8). Essy said:

*Yes, it can be leveraged. But you must know who the indigenous knowledge holders are. Involve indigenous knowledge holders too in that process (FGI2-Q8).*

Essy focused on the development processes of epistemic border-crossing where the inclusion of IK to “that process” is necessary. This form of curriculum border-crossing according to Pete (2015) benefits indigenous students, teachers, and community members.

### **Evidence from Document Analysis (PoEs)**

The strategy to challenge epistemic othering through ideological border-crossing was visible in the PoEs that teachers produced and in their group presentations. Figure 41 below shows how Group Three was able to look at a mathematics unit of work and incorporate Ayurvedic IK:

CONTENT AREA	TOPICS	CONCEPTS AND SKILLS	SOME CLARIFICATION NOTES OR TEACHING GUIDELINES
NUMBERS, OPERATIONS AND RELATIONSHIPS	1.1 Whole numbers Division	<b>Properties of whole numbers</b> <ul style="list-style-type: none"> <li>Recognize and use the commutative; associative; distributive properties of whole numbers</li> <li>0 in terms of its additive property</li> <li>1 in terms of its multiplicative property</li> </ul>	Learners should check their calculations by multiplying: $202 \times 17 = 202 \times 10 + 202 \times 7$ $= 2020 + 1414$ $= 3434 + 13$ (NOTE: 13 is the remainder) $= 3447$ The size of the numbers required in Grade 6, means that methods used until now can become cumbersome. Now it is advisable to use the traditional long division method. The skills learnt in previous methods, will now be used in long division.

**Learner Activity**

1. A recipe to make 15 biscuits asks for the following ingredients:  
 300 g flour                      180 g sugar                      200 g butter

How much of each ingredient will you need to make:

a) 5 biscuits                      b) 10 biscuits                      c) 30 biscuits?

*A recipe to make a cough mixture for one person asks for the following ingredients:  
 250 ml milk                      2,5 ml turmeric                      1 ml ginger*

How much of ingredients will you need to make the cough mixture for two people?

Probe learners thinking by asking them the following questions:

- ❖ What they think they must do to increase the medication?
- ❖ What they think will happen if they only increase or decrease one ingredient?

Explain to learners that if you double one ingredient, you must double all.

**Figure 41: Epistemic othering within a learner activity presented in Group Three’s PoE (PoE3)**

Figure 41 first shows the CAPS extract where the selected unit of work was located:

*Section A shows an activity based on (the operation) Division in the “Platinum Mathematics Grade 6” textbook. It shows how using a blueberry cake recipe can be used to teach Division in mathematics. The blueberry is a very old plant that grows spontaneously in the north of Europe and America. In Spain, it is widely spread in the forests of mountainous areas. The use of the blueberry presented in this book reflects colonial examples used to teach mathematics in a global south context (PoE3).*

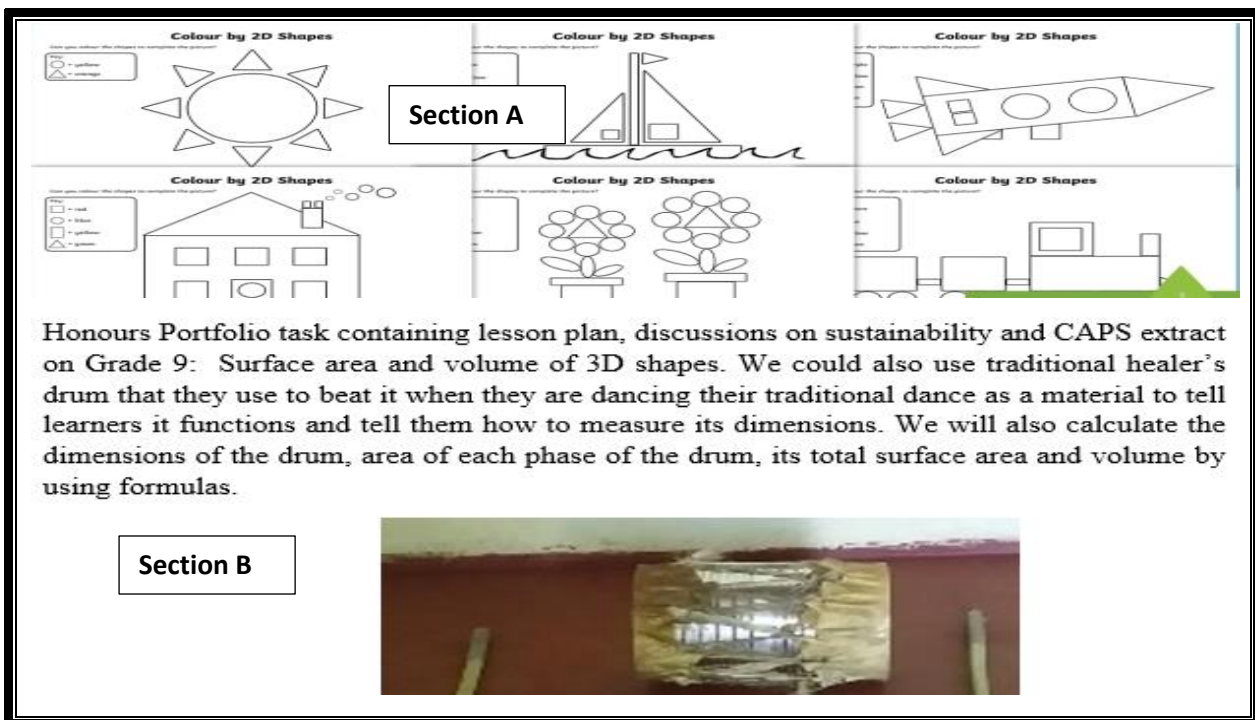
The group however also included Section B, in Figure 41:

*Upon consultation with the IK holder in our group, he noted that turmeric milk, many households use this as a homemade recipe to treat common*

*colds and the flu. We believe that teaching learners this recipe not only teaches them about the contribution of Ayurvedic and indigenous medicine, but they can also use this to keep themselves healthy (SDG: 3 – Good health and well-being). South Africa is a third-world country, and homemade recipes using readily available ingredients is key to promoting the well-being of citizens (PoE3).*

Group Three challenged epistemic othering by including elements of Euro-Western examples, Ayurvedic and indigenous examples as well as addressed SDG 3 in their unit of work on the Division.

Group Six also exemplified this ideology in their unit of work on “Measurements and Shapes” by including indigenous instruments with various dimensions. Figure 42 below shows an extract from an analysis of their PoE.



**Figure 42: Challenging of epistemic othering of IK within Group Six's extract (PoE6)**

Section A shows typical Euro-Western examples of 2D shapes like a rocket, a boat, and a modern house with which not all SA learners will be familiar. Section B, however, shows an African drum and sticks which could also be used to teach 2D shapes. Sections A and B, coupled with discussing SD issues within a single unit of work challenge the epistemic othering of IK.

Teachers selected various types of IK, ESD concepts, and units of work from the curriculum to merge and create a curriculum bricolage that foments transmodernity through interculturalism and dialogical ethics (Maldonado-Torres, 2011). This initiated a dialogue between humans and those considered sub-humans (IK holders and colonised people) and the formulation of a decolonial and critical cosmopolitanism (Maldonado-Torres, 2011). This challenging epistemic othering of IK was based on an “emergent indigenous paradigm” and “relational accountability” whereby the curriculum is “accountable for sustainability issues and created a space for knowledge of indigenous peoples” (Le Grange, 2016, p. 9).

### **5.5 Research Objective Two (b) To explore: Why science and mathematics teachers who have engaged in professional development activities use the strategies they use.**

This research objective explored the reasons why science and mathematics teachers who had engaged in PD activities used specific strategies when they engaged in planning to enact the school curriculum by incorporating IK to address SDGs. This question supports and supplements Research Question Two (a) which focused on the “types” of strategies teachers used. This question was explored by analysing teachers’ responses to FGI2 (which occurred after PD activities had taken place), and teachers’ reflections presented in PoEs.

#### **5.5.1 Theme One: Effective Teacher Professional Development**

Science and mathematics teachers used effective TPD strategies they were taught during their PD engagements during the study of the Honours module. These strategies in the view of teachers were most suitable to implement. Responding to Question 13, “What types of strategies did you use when leveraging indigenous knowledge to address Sustainable development Goals in the school science or mathematics curriculum?”, Will stated:

*The first thing was to do critical discourse analysis. Then I had to read about indigenous knowledge and consult with the indigenous knowledge holder to leverage indigenous knowledge (FGI2-Q13).*

By stating that “the first thing was” to do CDA, Will acknowledged that he resorted to using skills that he had acquired in the Honours module, especially when teachers reported not having had enough knowledge to address SDGs initially (as recorded in section 5.3.1). Question 14 of FGI2 revealed the reasoning behind teachers using the strategies they used. They were asked, “Why did

you use the strategies you used when leveraging indigenous knowledge to address Sustainable development Goals in the school science or mathematics curriculum? Explain". Precious stated:

*I just, that's the only thing that worked. It was what my lecturers taught me in the Honours module (FGI2-Q14).*

Sbu shared similar sentiments when responding to the same question:

*We used them because it was what we were taught in the Honours module. The lecturer emphasized Critical Discourse Analysis and consultations with the indigenous knowledge holder (FGI2-Q14).*

Sbu's learning was heightened by applying CDA to textual material and consulting with IK holders as part of the PD activities included in the Honours module. This is consistent with de Sousa Santos' (2015) contention that teachers adopt what they learn during PD programmes. Will explained his choice of pedagogic strategies to his learning during the PD programme. He said:

*These strategies are researched and are proven. Our lecturers and literature motivated for these strategies, and we used them (FGI2-Q14).*

By referring to "research", Will attributed his strategies to engagements with lecturers and literature, both of which were present in the context of the Honours module. I observed some of the lectures from the science and mathematics Honours module which formed a part of my field notes dated the 25<sup>th</sup> of July 2021 and recorded the following: "teachers were shown how to use CDA to identify colonial elements in units of work and examples of how to link IK and certain SDGs to these" (FN). Below in Figure 43 are some extracts from four PowerPoint slides that were used during the lecture demonstrating how to leverage IK to address SDGs in a unit of work.

**Slide one**

- Grade 7 : **Unit of work: Multiplication, division, percentages and ratio's** (CAPS, p. 27). Inviting a knowledge holder of Asian or Arabian decent to explain the rationale behind the clay oven and its construction. Life histories.
- Cooking using conventional appliances or using a clay oven, which leaves the largest Carbon Footprint?
- Cost of transporting food
- 1 gallon of petrol produces 8.87kg of CO<sub>2</sub>, how much would 10 gallons produce? 50? 100? What is the ratio of petrol to CO<sub>2</sub> Emission?
- Locally produced food travels an average of about 200 miles from farm to shop, Long haul air freight emissions are 570 g CO<sub>2</sub> per ton kilometer.

**Slide two**


Unit of work:  
Grade 7 :  
Multiplication  
, division ,  
percentages  
and ratio's

Numbers, Operations and relationships (CAPS, p. 39).

Colonial elements: E.g. Calculation of % gallons of petrol, Miles travelled by vehicles etc.


Calculations focused on determining the Carbon Footprint from different human activities.

Equivalent and percentages (CAPS, p. 122)




**Slide three**

Links to  
Indigenous  
Knowledge



- In Arabian, Palestinian and Middle-Eastern societies, bread was often baked within a clay oven called a Tanur or Tannour.
- Allowing learners to learn from Arabian or Asian knowledge holders about their technologies.
- The indigenous clay oven consumes 69% less wood than a traditional oven. Each oven can around 1.27 tons of wood each year while reducing carbon emissions by 2.73 tons over the same period of time.
- Discuss the bread making process, IK ingredients used, construction, economical and environmental impact.



**Slide four**

Links to SDGs


SDG 13: Drop in the carbon emission from the use of the clay oven would lead to a cleaner planet better health.

SDG 3. Drop in the carbon footprint.

SDG 7 : Cheaper alternative.

SDG 12: Consuming wood in a more sustainable manner.

SDG : 11: Linked to the above.



**Figure 43: Extracts from Powerpoint demonstrating examples of including IK to address SDGs (science and mathematics Honours lecture)**

The purpose of Slide one was to offer teachers information from the curriculum which can be linked to examples from the South when teaching and learning a selected topic. Slide two highlighted colonial elements and possible opportunities to include IK in the unit of work. Slide three discussed possible IK that could be leveraged in the selected unit of work and Slide four discussed how SDGs could be taught. This was consistent with how I reported teachers enacted an alternative curriculum that addressed the SDGs (in section 5.4.2.2) above.

Will, Precious, Josh, and Umdwebi in Group Two included their PowerPoint presentation in their submission of their PoE (PoE2). A review of this (using the document analysis template; criteria 11. The nature and type of support materials used to plan the unit of work which leverages IK and addressed the SGDs [Appendix D]) revealed that there were a few similarities between this and the presentation presented by the lecturer in the Honours module in Figure 43 above. Figure 44 below is extracted from Group Two's Powerpoint presentation in PoE2 that they used during their micro-teaching presentation to the science and mathematics Honours cohort.

## DETAILS OF LESSON


**Grade:** 6

**Subject:** Mathematics

**Topic:** Geometric Patterns

**Specific Aims:** Refer to table

**Assessment:** Informal



Slide one


<b>KNOWLEDGE</b> Learners should gain knowledge and understanding of the following:	<ul style="list-style-type: none"> <li>Concept of geometric patterns</li> <li>Increasing patterns</li> <li>Traditional Zulu beadwork</li> </ul>
<b>SKILLS</b> Learners should be able to do the following:	<ul style="list-style-type: none"> <li>Describe geometric patterns</li> <li>Determine the next shape in a geometric pattern</li> <li>Create a geometric pattern</li> </ul>
<b>VALUES/ATTITUDE</b> Learners should acquire values and attitudes conducive to promoting:	<ul style="list-style-type: none"> <li>Appreciation of traditional Zulu beadwork</li> <li>Awareness about poverty, quality education, decent work and economic growth, and responsible consumption and production.</li> </ul>

## LINKS TO INDIGENOUS KNOWLEDGE

Zulu beadwork is not only beautiful, but is also rich in tradition and cultural meaning. What makes this intricate craft and art unique is the use of decorative geometrical designs, particularly the triangle, and colours to convey a message.

Beadwork is practiced by Zulu women and is passed down through generations by the older women in the family. They become communities of their own and are empowered by their skill and contributions to their communities.

Slide two



## Linked to SDGs

**SDG 1: No poverty** - Learner can be made aware that crafting and selling beadwork is a viable option to earn money and provide for the needs of their families.

**SDG 2: Zero hunger** - Selling beadwork creates income which can be used to buy food and feed families.

**SDG 15: Life on land** - By producing beadwork from natural seeds and recycled material, learner can learn about caring for the environment. Glass and plastics usually pollute the land and harm many organisms.

Slide three

**Figure 44: Extracts from Group Two's teacher group Powerpoint presentation**

Table 10 below shows a comparison between the Powerpoint presented at the science and mathematics Honours lecture and the Powerpoint presented by Group two on leveraging IK to address the SDGs.

**Table 10**

***Differences and similarities between the Powerpoint presented at the science and mathematics Honours lecture (presented on 25/07/2021) and the Powerpoint presented by Group Two (presented on 05/08/2021), on leveraging IK to address the SDGs***

An exemplar of PowerPoint presentation used by lecturers during science and mathematics Honours lecture	Group Two's Powerpoint presentation at a micro-teaching session
<b><i>Differences</i></b>	
Focused on a Grade 7 mathematics unit of Work, on Multiplication, Division, Percentages, and Ratios.	Focused on a Grade 6 mathematics unit of Work, on Geometric patterns.
Presented example focused on a variety of cultures and IK ideas, cited Middle eastern.	2. Focused only on the Zulu culture and IK.
The presentation opted for narrative and storytelling pedagogies based on narrating the use of indigenous technologies over the years.	3. The group offered details on Knowledge, skills, and values with some focus on practical work using beadwork.
<b><i>Similarities</i></b>	
Both focused on a mathematics unit of work.	
Both addressed five SDGs each with SDG 12 – Responsible consumption and production, being common.	
Both included IK related to a specific cultural group. The pictures included in both show a person/people making something. The picture of a “potter” in the lecture presentation and the picture of people with beadwork in Group Two's presentation.	
Both used a similar presentation structure. They presented the curriculum content related to their selected unit of work. They presented the IK and SDGs on separate slides respectively.	
Both presented the content knowledge in the context of the IK that could be leveraged and the SDGs they address in a narrative format.	

<b>Lecture Powerpoint extract</b>	<b>Group Two's Powerpoint extract</b>
<ul style="list-style-type: none"> <li>• The indigenous clay oven consumes 69% less wood than a traditional oven. Each oven can around 1.27 tons of wood each year while reducing carbon emissions by 2.73 tons over the same period of time.</li> </ul> <p>Reference to the clay oven (IK).</p> <p>Reference to percentages and numbers (mathematics concepts).</p> <p>Sustainable development issues are linked to sustainable consumption using clay ovens and reduced carbon emissions (SDGs).</p>	<p>Zulu beadwork is not only beautiful, but is also rich in tradition and cultural meaning. What makes this intricate craft and art unique is the use of decorative geometrical designs, particularly the triangle, and colours to convey a message.</p> <p>Beadwork is practiced by Zulu women and is passed down through generations by the older women in the family. They become communities of their own and are empowered by their skill and contributions to their communities.</p> <p>Reference to Zulu beadwork (IK).</p> <p>Reference to “geometric designs”, and “triangles” (mathematics concepts).</p> <p>Sustainable development issues are linked to Zulu women empowerment (gender issues) communities (Partnerships) and oral educational traditions (quality education) (SDGs).</p>

My analysis of the presentations by the lecturers and those by the teachers revealed commonalities at an ideological and organizational level. The IK that both groups used was focused on the production of a culturally significant “object/tool”, namely the clay oven and beadwork. The lecture presentation served as a guide for teacher groups to present their unit of work from the science and/or mathematics curriculum.

This finding was further expressed through the reflections of teachers (Appendix E). Will recorded the following reflective entry on 01/05/2021:

*through working with the assignment, I researched information on critical thinking skills, as well as reviewed lecture content based on the use of Critical Discourse Analysis that was done in the module and I found that my critical thinking skills had changed in many ways (RJ).*

Will showed a dependence on the materials and skills that were provided to him to engage with IK and the SDGs during the PD programme. Cat referred to the specific activity in her reflection:

*Through the participation (in) this task, it has made me more aware of my teaching and the different indigenous knowledge that can be used, it has taught me to give*

*credit to where it is due and not just based on western knowledge but our own country's achievements (RJ-22/04/2021).*

Both the responses and reflections from teachers showed that the pedagogical practices learned by teachers through TPD engagements were effective enough to allow them to successfully leverage IK to address the SDGs in the science and mathematics curriculum. They adopted the tools that they were exposed to in the Honours module when decolonising their selected units of work.

### **5.6 Research Objective Three: To explore: The experiences which constrain or enable teachers who seek to address the sustainable development goals by leveraging indigenous knowledge.**

**(a) The factors that obstruct or enable when leveraging IK to address the SDGs in the school curriculum.**

**(b) How science and mathematics teachers respond to these factors.**

This research objective first sought to understand what factors enabled or obstructed teachers who sought to address the SDGs by leveraging IK. Secondly, it focused on gauging how teachers responded to the obstructive and enabling factors. Parts (a) and (b) of “research question three” guided my analysis and are presented separately. Focus group interviews and teachers’ reflections revealed valuable information which contributed to answering this research question.

**To explore: (a) The factors that obstruct or enable when leveraging IK to address the SDGs in the school curriculum.**

#### **5.6.1 Theme One: Obstructive Factors**

##### **5.6.1.1 Factor One: Time Management**

Time management in the context of teaching and curriculum responsibilities proved to be an obstructive factor for teachers who engaged in PD. The United Nations Educational, Scientific, and Cultural Organization (2020) identified the time factor as an important consideration when teachers

implement ESD in the classroom. Sbu, in responding to Question nine of FGI2 was asked to, “(...) share experiences of working within a group to complete your assessment task”. He said:

(...) it took a lot of time, for me, I spent a lot of time doing this assignment, so, yeah, it was time-consuming (FGI2-Q9).

The repetition of the word “time” with terms like “it took”, “spent a lot” and ‘consuming” iterated the obstructive nature that a lack of time management had posed to teachers. Will also highlighted time management as a challenge for him to be able to leverage IK to address SDGs. Teachers were asked “What were some of the challenges related to leveraging indigenous knowledge to address Sustainable development Goals in the school science or mathematics curriculum that you encountered?” in Question 16 of FGI2. Will said:

*Linking the topic to the SDGs was quite difficult. Finding the time and the resources to engage in this type of teaching was also a challenge (FGI2-Q16).*

Essy said that the decolonisation process “needed a lot of planning and time” in her response to FGI2-Q16. Question 17 of FGI2 was direct “What factors are obstructive or enabling when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum?”. Responding to what was obstructive, Essy simply said, “Time, I used weekends for the excursion” (FGI2-Q17). The excursion Essy referred to, was a trip she took to visit an IK holder in her village. Time was an obstacle in the planning of lessons and during learner activities. Will was able to organize his time to carry out some PD activities, yet still cited “time” as a weakness for his group. Will’s reflection from 23/04/2021 read as follows:

*Our assignment required a good amount of time for us to be completed by the due date (...) time allocation seemed to be a weakness as at the outset of the task (Will’s RJ-23/04/2021).*

### **5.6.1.2 Factor Two: Lack of Teacher Capacity**

Another major obstructive factor that science and mathematics teachers who engaged in PD experienced in planning to leverage IK to address the SDGs was the lack of capacity in terms of knowledge about concepts. Lotz-Sisitka et al. (2017) contend that there is generally a deficiency in IK-related, locally relevant contributions to SD to address Agenda 2030. Responses from the teachers from FGI2 and Reflections resonated with Lotz-Sisitka et al.'s (2017) contention. Question

16 of FGI2 based on understanding the challenges related to leveraging IK to address SDGs in the school science or mathematics curriculum revealed the following response from Precious:

*For me, I didn't have a lot of experience with indigenous knowledge, be it African or Indian or whatever it was. I don't have a lot of experience with it (...) I didn't know practices that I could use, I didn't know rituals and ceremonies (FGI2-Q16).*

Precious categorically stated that she did not have 'experience' or even knowledge about IK. Cat answering the same question, said, "it was not having background knowledge of these topics and the links of how it does respond with indigenous knowledge" (FGI2-Q16). Sbu's response to Question 16 further highlighted how the lack of knowledge and capacity about IK and the SD, was an obstructive factor. Below is his response:

*Sbu: For me, it was just understanding what sustainable development is. Like the whole concept of it, I was really struggling. As far as even now, I am still struggling with it (FGI2-Q16).*

Teacher reflections revealed similar sentiments on the lack of knowledge that they had. The concepts related to the SDGs and IK were additions to the knowledge bases of teachers. They had limited capacity to understand IK and the links to the SDGs as shown in the response above, before studying the module. A lack of teacher capacity posed a challenge to teachers when they planned to leverage IK to address the SDGs.

## **5.6.2 Theme Two: Enabling Factors**

The enabling factor/s were also understood through an analysis of teachers' responses to FGI2 and from their entries in their reflective journals.

### **5.6.2.1 Factor One: Democratic Interactions**

Teachers cited a few underlying factors that enabled them to leverage IK to address the SDGs in the school curriculum. When analysed, these factors are all related to the practical enactment of what Le Grange (2016) calls democratic interactions. Le Grange (2021) bases the *Ubuntu-currere* on the fundamental idea of democratic interactions. The *Ubuntu-currere* came alive in the Honours

module because various relationships and academic interactions were encouraged within a community context, which resonated with indigenous ideologies.

Professional development activities were not limited to what took place during the module lectures and tasks only. When asked to “(...) share your experiences of working within a group to complete your assessment task” (FGI2-Q9), teachers had the following to say:

*Dwayne: It (working within a group) was a pleasant and positive experience that broadened my perspective of knowledge in terms of indigenous knowledge as well as the science curriculum in general. It also provided me with insight (FGI2-Q9).*

*Will: It was also a great experience working with them because we got to share the work and discuss our views. Working collaboratively was really beneficial for us (FGI2-Q9).*

Dwayne identified working with his group as a “pleasant and positive experience”. Will noted that “Working collaboratively was really beneficial”. Both statements pointed to collaboration as a factor that was enabling when leveraging IK to address SDGs. When Cat was asked “What factors are obstructive or enabling when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum?” (FGI2-Q17), her response included:

*Enabling was having lecturers and the indigenous knowledge holder who understood the role of different knowledges and how it could help us (FGI2-Q17).*

Precious said that “It was enabling to work within a cohort and especially within a group to share ideas and learn from each other” (FGI2-Q17). Sbu also noted an unplanned interaction with the module lecturer in his response to FGI2-Q17:

*I ended up contacting the lecturer, I remember calling towards half-past nine at night, late. And he just gave me some assistance and it was helpful, then I started working (FGI2-Q17).*

This unplanned interaction was helpful to Sbu. Will referred to the various people he developed professional relationships with within the module when asked what was enabling him:

*What enabled me to complete this was having the support of my peers and the lecturers to assist in this work. The indigenous knowledge holder and the researcher also enabled me to work better (FGI2-Q17).*

Cat, Precious, and Sbu, all referred to the power of community and democratic interactions to develop the curriculum. This consisted of engagements between teachers, lecturers, and the IK holders in the form of parents, community elders, and artisans. Will explained how he consulted lecturers, his peers, the IK holder, and even myself (the researcher) in his response to FGI2-Q17. Precious engaged with IK holders by “asking my mother” (...) she also told me about the artisan (who served as the IK holder in my group) who works there (FGI2-Q17). All interactions took place in a united manner, whereby power hierarchies were minimised through the notion of everyone being a Black-African person, therefore being “one”.

Le Grange (2016) believes that a focus on the oneness of the self and other humans provides an impetus for becomings. In this case, the “becomings” related to teachers becoming teachers who were able to plan to leverage IK to address SDGs.

Reflections from teachers presented similar views on what factors were enabling when leveraging IK to address SDGs in the school curriculum. Thobisa’s reflection from 06/04/2021 showed how consulting and interacting with the IK holder enabled him to plan effectively:

*I consulted one of my community elders who does beadwork and sells it. Her explanations made it easier for me to include practical and African examples that could be used in grade 4 Geometric patterns (RJ).*

Consulting the IK holder and understanding “her” work with regard to beadwork “made it easier for” Thobisa “to include practical and African examples”. This was an enabling factor for him. The practical enactment of collaboration in the curriculum was able to fulfill teacher group objectives but also reveal insights to individual teachers as observed by Thobisa’s view that “Her explanations made it easier for me”. The notion of *ubuntu* according to Le Grange (2016, p. 9), enables the decolonisation of education by exploring alternative pathways for existing in the world. In the context of my study, this meant a move toward ESD. In my study, the notion of *ubuntu* was unlocked through various democratic engagements.

### **5.6.3 Research Objective Three: To explore: (b) How science and mathematics teachers respond to these factors.**

Each teacher responded uniquely to the factors that enabled and obstructed them when leveraging IK to address the SDGs. They reacted by seeking support and solutions when they experienced factors that obstructed their PD process. In respect of the factors that were enabling, teachers reacted by maximizing their experience with that specific factor.

When addressing the obstructive factors (which were “time management” and “lack of teacher capacity”), teachers drew on the “expertise of more knowledgeable others” like their lecturers and IK holders. They also responded to these obstructive factors by developing teacher agency by conducting their own research and literature reviews. When responding to factors that were enabling which were based on democratic interactions, teachers sought more “critical engagements” from those interactions (i.e., with IK holders, and lecturers).

### **5.6.3.1 Theme One: Expertise of knowledgeable others**

Sbu responded to FGI2-Q16 and spoke about his challenges related to understanding SD. When asked in FGI2, Question 17 “How did you respond to these factors?” Sbu said that he contacted his lecturer and received assistance (as presented above). Sbu’s first reaction to the obstructive factors he experienced with regard to leveraging IK to address SDGs was to contact one of the lecturers teaching the science and mathematics Honours module. Sbu reports to have gotten “assistance” and “it was helpful”. Precious also responding to obstructive factors (FGI2-Q17) drew on the expertise of her mother who is a teacher, and the IK holder. She said:

*I responded to it by asking my mother (...) She works at a special school, she also told me about the artisan (who served as the indigenous knowledge holder in my group) who works there (FGI2-Q17).*

*Ubuntu* according to Oelofsen (2015) which is so persistent in the existence of African people, often tends to be the first response to those facing adversity. Precious spoke about responding to obstructive factors by first, asking her mother for help. Secondly, Precious responded to obstructive factors by looking for the “artisan” who is a more knowledgeable person regarding IK and his craft.

Will's response to FGI2-Q22 captured how most teachers responded to the obstructive factors, as follows:

*Whenever I found something related to leveraging indigenous knowledge to address the SDGs to be difficult, I would react by emailing my lecturer or send a WhatsApp to*

*my group mates which included the indigenous knowledge holder because some of them had more knowledge (FGI2-Q22).*

Will sought expertise from people who in his view appeared to be more knowledgeable than others. Reflections also revealed similar information. Teachers asking indigenous people outside the education sector for assistance was powerful. It challenged those who were seen as holders of powerful knowledge in conventional HEI settings (Mudaly, 2018a). Teachers got advice to expand on content and pedagogy strategies to complete the set task which also contributes to dealing with the challenge of managing time.

### **5.6.3.2 Theme Two: Teacher Agency**

I lean on Knowles (1975), cited in Towle and Cottrell (1996), to describe teachers' development of their agency. I am cognizant that focus on self and agency is a Euro-Western construct. However, I subscribe to a plurality of knowledges for the development of ESD in the SA context. Teacher agency is linked to the discussion of curriculum as an Autobiographical method (as discussed in Chapter Three). This is in keeping with Le Grange's (2021) notion of the *Ubuntu-currere* which does not seek to create knowledge hierarchies. Combining my understanding of currere to Le Grange's (2021, p. 13) *Ubuntu-currere* "which provides one form of decolonisation and presents not only a way of decolonising the self, but also disrupts dominant approaches to curriculum configured in the Euro-Western mould". Individual liberation in a global South context, however, "occurs in intra-action with other humans and the more/other-than-human world – the self is embedded in society and the cosmos" (Le Grange, 2021, p. 14).

Teachers noticed that they could respond to obstructive obstacles by developing agency (focused on self-learning) by conducting extensive research and literature reviews related to required concepts in their units of work (as discussed in section 5.4.2.2). They did not merely focus on dominant colonial narratives to plan to teach units of work. Cat responding to FGI2, Question 17 gave an account of how she responded to obstructive factors related to her PD. She said:

*By not having that background knowledge it did seem difficult to move forward. And unless you do your research and actually plan ahead. We have to plan and have that background knowledge and do our research (FGI2-Q17).*

Cat identified that she needed to respond to “not having that background knowledge” by doing research. And since she was working within the context of a teacher group and within broader engagements with her peers, this response formed a part of what most teachers did. Essy answering FGI2-Q17 also cited the literature review process as an important response to the obstructive factors:

*Making connection between indigenous knowledge, sustainable development, and science content, I would read, read again try to understand each concept separately, analyse and make a link (FGI2-Q17).*

The intentional “reading” for analysis that Essy did was an important response to lacking knowledge on IK and SD especially. Research and literature reviews were extended responses that teachers used.

Will discussing Question 13 of FGI2, “What types of strategies did you use when leveraging indigenous knowledge to address Sustainable development Goals in the school science or Mathematics curriculum?” a part of his response was:

*(...) I had to read about indigenous knowledge (...). Research and reading were vital (FGI2-Q13).*

Will’s answer to Question 13 included “read” and “reading” emphasizing the importance of responding to obstructive factors by reviewing the literature. Teachers took this self-determined initiative to engage in extensive research and literature reviews as a response to the obstructive factors related to leveraging IK to address SDGs. These decisive processes of self-learning not only opened a myriad of information for teachers to be exposed to but also saved a lot of time that would have otherwise been spent procrastinating and developing uninformed decolonial units of work. The self in this instance refers to the collective ‘self’, as teachers worked organically in groups. This epistemic journeying which teachers embarked on through their agency led to the exploration of relational epistemologies, which acknowledges all sources of knowledge, within their historical and sociocultural contexts, as valuable and worthy of dialogue.

This development of agency that teachers embarked on is inherently linked to what Maldonado-Torres (2011, p. 27) terms “decolonisation of the being and the mind” as discussed in Chapter Two. Black-African and Black-Indian teachers (in a South African context) took ownership of their learning, as opposed to accepting the colonial epistemologies that dominate ESD and basic science pedagogies in the academy. This self-learning response that teachers adopted was developed

during their PD in the Honours module. Teacher consciousness and capacity to critique curricula were enhanced through various PD activities which included “self-study using prescribed reading material (including policy documents, peer-reviewed articles)” (FN). The understanding of self in relation to others (in this case in the teacher group) was important. Marshall and Reason (2007, p. 369) propose that “quality is about becoming”, which can be extended to the *ubuntu* sense of, I become because of you; in relation to you (Keane et al., 2017). Marshall and Reason (2007, p. 374) articulated the ineffable nature of such knowing: “Experiential knowing . . . is knowing through empathy ...in relation to others”.

Teacher agency was developed through teacher learning which was based on the process of ‘consciousness raising’ which teachers experienced. Teachers reflected on the “ideology that underpins the curriculum” (Mudaly & Sanjigadu, 2022, p. 22). Teachers lamented the effects of colonisation on present-day education. Teachers exercised their fully conscious human status being free from coloniality (Madlingozi, 2017) and took ownership of their learning (Mudaly & Sanjigadu, 2022). This show of agency is a movement from dependence on others who are seen as a more knowledgeable other and redirection to value and strength within the African “being (self)” which was evident when the IK holders selected their pseudonyms i.e., Imbokodo, Amandla, Nkunzi and Umdwebi, terms which were explained in Chapter Four.

### **5.6.3.3 Theme Three: Critical engagements**

Democratic engagements were enabling when leveraging IK to address SDGs in the school curriculum. Teachers identified that the support from stakeholders (other teachers, IK holders, Lecturers, etc.) present in the Honours module was highly beneficial and therefore responded by exploring more critical engagements with stakeholders present in the PD process.

Essy shared a similar engagement she had with the IK holder she selected. Discussing her experiences working with the IK holder, Essy said:

*Well, it was an amazing experience because the female elder I was working with was very rich in knowledge about soil fertility. She was warm and welcoming to my learners and patient too (FGI2-Q10).*

Essy invited the IK holder (who she had worked with on the excursion) to her actual classroom, which was not a requirement of the Honours module or this study. Essy identified that the

engagements with the IK holder were enabling and decided to undertake more critical engagements with the IK holder by taking her (the IK holder) to her place of work (Essy's school). Essy elaborated on this engagement in Question 13 of FGI2 "What types of strategies did you use when leveraging indigenous knowledge to address Sustainable development Goals in the school science or mathematics curriculum?". She said:

*I simply did interviews with the elder, and then observed her using organic fertilizers and working with learners too (FGI2-Q13).*

By interviewing the IK holder and letting her (the IK holder) teach learners about "organic fertilizers", Essy's engagements with the IK holder went beyond the bounds of the module and my study into realms of more critical pedagogical engagements. Essy exposed learners to the IK holder as more than just a resource person to a teacher and a holder of valuable knowledge.

Question 22 of FGI2 was "How has participating in this project developed your science or mathematics and professional development skills?". Teachers' responses to this question revealed the intricate engagements they undertook with various individuals as a response to the enabling factors experienced. Precious' response included:

*(...) interaction with the researcher, he has a lot of experience with this or just a lot of knowledge regarding the topic (...) and I don't cross many people who talk about this sort of thing. So, it was great (FGI2-Q22).*

Precious' views on the researcher having 'a lot of experience with this' and not crossing "many people who talk about this sort of thing" showed the deep scholarly interaction. The engagements moved towards more of a partnership in knowledge creation and exploration which was deeper than initially envisaged. Will, in responding to Question 22 (FGI2) said:

*I would react by emailing my lecturer or send a WhatsApp to my group mates which included the indigenous knowledge holder (FGI2-Q22).*

His response of emailing his "lecturer" and sending social media messages to his "group mates" showed the interactive relationship that Will developed with people present in the learning process. Will stated that his reaction included sending "a WhatsApp to my group mates which included the IK holder". He referred to the IK holder as one of his "group mates" which is a change from the IK

holder being just a resource person or a consultant. This speaks to the development of a deeper relationship between IK holders and teachers in this study.

Reflections also revealed that teachers responded to enabling factors by undertaking more critical engagements with those present in the learning process. Sbu's reflection on 04/04/2021 showed the nature of his critical engagements with the IK holder:

*For this project I was blessed to work with a 55-year-old grandmother, she is part of school governing body at my school. She resides a little bit far from the school. I approached her to request her to teach my learners about fertilizer specifically organic or traditional fertilizer (RJ-04/04/2021).*

Sbu reports seeing the IK holder as a "blessing" to him and his learners. He "approached her (the IK holder) to request her to teach my learners about fertilizer specifically organic or traditional fertilizer". Sbu initiated the critical engagements with the IK holder as a response to the enabling factor of initially engaging with her. Sbu's knowledge of personal information like the IK holders' role as a school governing body member, her residence and even inviting her to an excursion is a testament to the critical engagements that were had. Cat's reflection below encompassed the way the critical engagements with others present in the learning process were something teachers sought after as a reaction to prior engagements which were enabling to them:

*Our indigenous holder is a 60-year-old Zulu male who has shared his knowledge with us, through this invaluable experience, we were able to not only have our questions answered but gained a lesson on how the inclusion of this knowledge can make a difference in our learners' education and contribute to sustainable development (Cat's RJ -16/04/2021).*

The engagements that Cat's group had with the IK holder (a community elder) exposed them to the "elder's reality" which expanded to not just having "questions answered", they "gained a lesson on how the inclusion of this knowledge can make a difference.

In Question 20 of FGI2 teachers were asked to elaborate on the PD they gained about decolonisation, IK and SD, they had the following to say:

Dwayne said that he understood the concepts and acquired valuable knowledge. Will spoke about becoming aware of the link between decolonisation and indigenous knowledge and conscientising

himself with sustainability and how these concepts can be addressed through the teaching of his subject.

The PD that teachers underwent created spaces for deep teacher reflection on the ideology that underpins the curriculum. They understood their subaltern status fully, and were aware that scientists from the North are positioned as barometers and moderators of true, valid knowledge, making it necessary that “whatever that we do we have to pass by them”. Teachers understood the intellectual authority (Connell, 2007; De Sousa Santos 2007; Mignolo 2011) that is attributed to knowledge producers from the North. But they also expressed the need to disrupt this knowledge hierarchy through leveraging IK (Mudaly & Sanjigadu, 2022).

Teachers like Essy and Group five planned to engage their learners in hands-on activities as they reclaimed IK into the mainstream CAPS curriculum. During Essy’s engagement with the IK holder, she went to the IK holder’s home, saw real life materials, such as soil and fertiliser, which would be handled by learners in concrete ways. The skills of following instructions, preparing soil and protecting soil and its organisms when creating beds for planting were learned through direct experience. Learners would literally connected to the earth, and this conscious link to the human and non-human would be strengthened. The IK holder and Essy worked together in planning to teach learners.

The teachers grappled with the process of IK and SD integration. The nuances between the different teacher explorations and the influence of the subject as well as the specific topics that the teachers/ participants used for the task was presented in the section 5.4.2 Theme Two: Re-imagination and Enactment. Further revelations were shown when teachers were asked “would you recommend leveraging indigenous knowledge to address Sustainable Development Goals within other subjects? If so, which subjects?” (Q21-FGI2) teachers proposed various subjects they thought would be ideal to leverage IK and address SD. Here I focus on what teachers said and when the curriculum was involved, I report on details of the topics that teachers proposed. It is important to note that these teachers conceptualized these topics to be able to leverage IK and the SDGs after undergoing their PD. Cat said “This is so ideal for Geography because there are so many aspects in “Poverty, Equality, in Water, in Recycling”, in everything.” Sbu identified Life Skills in Primary school which he linked to sustainable infrastructure and sustainable economies. Will said that he thought it can be used in all subjects, the languages, the Humanities and the sciences because sustainable development is something that we should all be concerned about in all spheres of life.

They familiarized themselves with a “new” intellectual world by engaging in intercultural dialogue (Barreto 2014), and self-directed research, to learn about a plurality of knowledges which included IK (Mudaly 2018). Teachers identified different traditional practices with a common biochemistry, like fermentation (Group One).

## **5.7 Conclusion**

The initial PD that teachers undergo through their undergraduate and in-service teacher training did not equip them with enough skills and knowledge to address the SDGs through leveraging IK. The CAPS documents, textbooks, policy documents, and support materials issued by the DBE in the context of this study, did not fully reflect decolonial and ESD reforms in keeping with the South African National Development Plan 2030 (National Planning Commission, 2015). This was observed from the colonial elements present in the CAPS documents and textbook extracts that teachers presented in Section 5.4.2.2.

This study was based on addressing SDGs by leveraging IK through exploring the “Experiences of science and mathematics teachers” who underwent PD through the study on an Honours module. Findings revealed that teachers address the SDGs in vague inexplicit ways in the school curriculum. My study then explored the subsequent integration of SDGs through leveraging IK within the curriculum, which was a PD exercise within the study of a science and mathematics Honours module at a teacher education institute in SA. Through various data collection processes, I was able to explore the types of strategies teachers who have engaged in PD activities use when they plan to enact the school curriculum when leveraging IK to address SDGs.

Teachers committed to exploring indigenous pedagogical and content strategies. Science and mathematics teachers were also committed to engaging in re-imagination and enactment of a decolonised curriculum. This was achieved by teachers reconceptualizing various SDGs within units of work from the science and mathematics curriculum through IK and enacting this reconceptualization through a lesson presentation and development of teaching and learning material. Furthermore, science and mathematics teachers worked with other teachers and IK holders adopting *Ubuntu-currere* ideologies.

I then explored why science and mathematics teachers who have engaged in PD activities use the strategies they use. It was evident that the reason for teachers using the strategies they used was

that the TPD processes that they underwent offered effective strategies to leverage IK and address the SDGs.

I then presented information based on ascertaining factors that are obstructive or enabling when leveraging IK to address SDGs in the school curriculum with a further exploration of how science and mathematics teachers respond to these factors. Factors that were observed to be obstructive when leveraging IK to address SDGs in the school curriculum were “time management” and a “lack of teacher capacity” in terms of knowledge about IK and the SDGs. Factors that were enabling were the democratic interactions in which teachers were involved.

Teachers respond differently to the various factors that they encounter. To the obstructive factors, teachers responded by drawing on the “expertise of knowledgeable others”. Teachers also responded to obstructive factors by developing their agency. Teachers reacted to the enabling factor by exploring more “critical engagements” to maximize the skills and knowledge they got from their collaborations with the various individuals present during the PD activities. The data presented and the first level (descriptive) analysed in this chapter was based on theoretical constructs and my understanding of the literature reviewed, the components of which were adapted to the context of this study. In the next chapter, I will present a deeper analysis related to each of the themes that emerged in this chapter.

## Chapter Six

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## **6.1 Introduction**

This chapter will offer a further level of abstraction that brings the evaluative analysis of Chapter Five into dialogue with the presentations made in the literature review chapter and the theoretical lens developed for this study. I address each research objective by offering evaluative analysis related to each theme that emerged in Chapter Five. I conclude this chapter by offering a discussion of the findings of this study.

## **6.2 Evaluative analysis related to Research Objective One: To explore How science and mathematics teachers address SDGs by leveraging IK.**

### **6.2.1 Analysis of Theme One: Teachers addressed SDGs using IK in sparse, indirect ways**

Chapter Five revealed that science and mathematics teachers address the SDGs by leveraging IK addressed in sparse, indirect ways. Lotz-Sisitka (2017) notes that the National Environmental Education Programme supported the emergence of the ESD Strategy in SA but concentrated more on piloting models for the PD of subject advisors than on formal teacher education programmes. Sinakou et al. (2018) believe that academics (and teachers) in the field of ESD do not conceive the concept of SD holistically and therefore cannot teach it effectively. Thobisa's sentiments in response to FGI1-Q6 are symbolic of this, when he said, "I don't remember the goal number but there is the other one about partnerships and working together that is the one that I mostly know." This shows that science and mathematics teachers in this study had a limited understanding of SD, which influenced how/or whether they address this in the curriculum.

In terms of the mathematics curriculum, researchers argue that SD and mathematics education remain largely unconnected in actual classrooms (Li & Tsai, 2022). Pipere and Mičule (2014) believe that the lack of PD linked to SD offered to teachers at HEIs can be attributed to the disjuncture between basic science subjects and education for sustainable development. Ismail (2017) notes that sustainability education in science and mathematics education is often neglected. Bamber et al. (2016) contend that the quantity and quality of ESD provision in teacher education are 'patchy' and scarce, which resonates with the data obtained in FGI1. For example, Nicki responding to "Question 8a" said that she was not offered professional development like specifically (about sustainable development....it wasn't...something emphasized.

The PD linked to SD that teachers received as revealed by the FGIs and reflections, were mere references or naming of concepts, and devoid of detailed discussions. This translated to how teachers leveraged IK to address SDG in the curriculum. It is evident within my study that addressing SDGs through IK is uncommon in science and mathematics classrooms. This resonates with Cronje's (2015) contention that teachers in South Africa do not implement IK effectively in the science and mathematics curriculum. In their analysis, Bentham et al. (2014) noted that indigenous knowledge barely featured in the content of subjects like science and mathematics and that very little attention was paid to solving social challenges using IK in the curriculum.

Tulloch (2019) believes that it is important that ESD is embedded in local contexts (which includes IK). Embedding ESD in teacher education programmes requires a strong commitment to understanding the significance of the social sustainability pillar, in which sustainability is about cultural survival as much as sustainability (Tulloch, 2019).

**Research Objective Two: To explore the pedagogical experiences of science and mathematics teachers who have engaged in PD activities in planning to address the SDGs by leveraging IK in the school curriculum.**

**6.3 Evaluative analysis related to Research Objective Two: (a) To explore the types of strategies science and mathematics teachers who have engaged in PD activities use to plan to enact the school curriculum when leveraging IK to address the SDGs.**

**6.3.1 Analysis of Theme One: Indigenous content and pedagogy**

One of the strategies that science and mathematics teachers who had engaged in PD activities used to plan to enact the school curriculum when leveraging IK to address the SDGs was to advocate for strategies related to indigenous pedagogy and indigenous content advocated. Wang et al. (2020, p. 37) recognize "indigenous pedagogies and indigenous content knowledge as a source of strength and sustainability through partnership with local communities to help transform the higher education sector."

The strategies that teachers used when leveraging IK to address SDGs in the school curriculum were inherently based on a commitment to retrieving indigenous content knowledge. Chilisa's (2012) commitment stage of decolonising the curriculum informed what content teachers planned

to include in their unit of work to address the SDGs using IK. Chilisa (2012) notes a commitment to decolonisation as raising awareness of the muting of colonised people. A commitment was shown by teachers when they demonstrated a desire to include voices of the colonised (the IK holders) by incorporating content and pedagogy sourced from IK holders. Keane et al. (2017) and Ogunniyi (2023) believed in the importance of teaching culturally inclusive lessons by integrating IK. Motala (2015) argued for a scholarship of integration (which is what I am aiming for in this study) through which the co-construction of knowledge goes beyond academic knowledge.

Teachers had to explore colonial elements in their unit of work. They used critical discourse analysis in order to do this. Sheng and Basaruddin (2014) support the use of indigenous games as a pedagogical practice to teach mathematical and scientific concepts to engage learner interest and reinforce the knowledge they already possess. Basic numeracy skills can be taught using indigenous games. For example, Moloji (2020) proposed the indigenous game called 'diketo' where stones were used to count. Raju (2017) notes that indigenous pedagogies like the pedagogy of play can be used to teach mathematics concepts especially.

### **6.3.2 Analysis of Theme Two: Re-imagination and enactment of a decolonised curriculum**

Another strategy that teachers used to leverage IK and address the SDGs was re-imagining a decolonised curriculum.

#### **(a) Re-imagining a decolonised curriculum**

Teachers in this study were committed to self-learning and learning from others in order to re-imagine the curriculum. In this way stages of dreaming (re-imagining) and commitment in Chilisa's (2012) conceptual model were interlinked and helped to unlock teachers' imaginations and got them thinking about the more contextually relevant curriculum they aspired towards. Re-imagined units of work in the science and mathematics curriculum reflected IK and ESD. Dreaming about the forms of IK content which Samuel spoke about as he aspired for teachers to "develop a way to impart IK into the classroom, yet still keep to content and maintain curriculum coverage" (FGI-Q2). Re-imagination according to Le Grange (2016) is linked to the "Dreaming stage" and is when colonised peoples aspire to include their histories, worldviews, and IKS to theorize and imagine alternative possibilities.

The discussions that teachers had with the IK holders created opportunities for them to imagine an alternative curriculum. Discussions, according to Davids (2018), provide reasons for people to abandon certain views to accommodate alternatives. The alternatives in this study were the de-centring of Euro-Western ideologies and the re-centring of IK within the curriculum for ESD. Lemaire (2020, p. 23) explains re-imagining as “the most significant phase, for it is when people explore new possibilities for a more equitable social order”.

### **(b) Enactment of a decolonised curriculum**

Mudaly (2018a) states that the implementation of procedures for change can allow for the valuing of IK. Teachers demonstrated how they would plan to leverage IK to address the SDGs. Identifying colonial elements in units of work, and scrutinizing these to find opportunities for the substantive, not tokenistic introduction of IK and the SDGs, occurred because there was an inherent commitment to action by teachers. This demonstrates the interlinking of conceptual frames of commitment and action (Chilisa, 2012).

In the context of this study, transformation involved working towards decolonising the curriculum to address sustainable development (Tikly, 2019). The units of work that science and mathematics teachers presented above impacted the three pillars of sustainability. Three teacher groups addressed SDG 15: Life on land (as presented above). This directly impacts the “Environmental Pillar” as the land serves the needs of all organisms living in the natural environment. Two teacher groups addressed SDG 1. Firstly, Group One discussed producing and selling “umqombothi”, whereas group two highlighted that beadwork used to teach mathematics topics can be produced and sold in order to feed families. These economic-driven ideas if implemented would directly impact local economies and the “Economic Pillar” as a whole. All teacher groups engaged with IK holders through social interactions, whilst there were groups like Group Eight that directly addressed SDG 17 leading to an impact on the “Social Pillar”, as this pillar focuses on interactions within societies.

Amado et al. (2017) identified the need to consider introducing and promoting ESD in teacher education institutions not solely as an issue of content, but also of how this content is taught, framed, and worked upon. Magni (2017, p. 437) notes that “the sustainable development agenda can benefit from different forms of traditional knowledge by exploring indigenous cultures and their knowledge systems in greater depth”. A case study conducted by Amado et al. (2017, p. 716) revealed the following finding, “the approach of professional development programmes to combine

human capacity and institutional structure building was effective in supporting the implementation and mainstreaming of ESD in teacher education institutions”. My study explored the human capacity development process by observing teachers' work towards decolonising the science and mathematics curriculums to address the SDGs.

### **6.3.3 Analysis of Theme Three: Teachers enacted *Ubuntu-currere***

The *Ubuntu-currere* according to Hlatshwayo et al. (2020) is pertinent to re-imagining teaching and learning in the South African education landscape. Science and mathematics teachers used strategies based on *Ubuntu-currere* ideologies by working with peers and IK holders through “collaborative engagements” and “challenged the notion of epistemic othering of IK” to leverage IK to address the SDGs.

The focus on democratic “collaborative engagements” through various PD activities that teachers engaged in including consultations with IK holders opened channels of discussion for knowledge sharing and knowledge merging between IK holders (who were community members) and teachers. In this way, teachers honoured indigenous culture and created a different space for engagement in keeping with what Keane et al. (2017) identified as an indicator of decolonisation at work. The collaboration between teachers during module interactions and FGIs created a new meaning for social interactions. The *Ubuntu-currere* switches our focus from individual accountability to relational accountability for the curriculum (Le Grange, 2019). Relational accountability means that all parts of the curriculum are connected and that the curriculum is accountable to all relations (human-human and human-nature) (Le Grange, 2019). These forms of engagement which included “varied voices” like those of IK holders led to the curriculum being enacted by challenging the epistemic othering of local knowledge.

Epistemic othering, by excluding IK in mainstream curricula, was challenged by teachers in my study who managed epistemological differences in the curriculum by coupling IK with Euro-Western knowledge within units of work. The constant epistemicide of African knowledge has rendered colonial epistemologies an unchallenged, dominant truth (Kaya, 2013). However, the focus on decolonial epistemic perspectives in my study created the opportunity to engage with what Dastile and Ndlovu-Gatsheni (2013) refer to as a plurality of epistemologies.

The examples in Figures 42 and 43 of Ayurvedic knowledge and AIK respectively, were incorporated into different units of work to address SDGs. These serve as examples of what Ani

(2013) views as leveraging indigenous and intuitive knowledge, as examples of Africa's epistemic pluralization within the curriculum. My study explored the teachers' creation of a reconstructed curriculum unit of work that drew on IK and ESD through the de-centering of Euro-Western ideologies and not the epistemicide of these. The disruption of the mainstream curriculum presented in my study is premised on Keet's (2014) contention that challenging the epistemic 'othering' of IK is in line with Fricker's (2007) notion of epistemic justice. Such epistemic justice endeavors aid in affirming indigenous epistemic identities (Keet, 2014).

#### **6.4 Evaluative analysis related to Research Objective Two: (b) To explore why science and mathematics teachers who have engaged in PD activities use the strategies they use.**

##### **6.4.1 Analysis of Theme One: Effective Teacher professional Development**

Teachers believed that the TPD they received from studying the Honours module was effective enough to enable them to address the SDGs by leveraging IK. Kwon et al. (2017, p. 121) cited the Three-stage practice-oriented framework for teachers noting that, "the first stage orientates teachers to PD processes. The second stage focuses on the development and sharing of lessons. While the third stage focuses on knowledge sharing and engagement." This form of practice-oriented framework informed the PD in my study. Tooley and Connally (2016) describe effective TPD as being demonstrated by teachers implementing what they learn.

Lotz-Sisitka et al. (2017) believe that PD practices that incorporate ESD are important for the sustainability agenda in SA. These PD practices should offer pedagogical knowledge that teachers can use to make use of indigenous ideologies (Lebeloane, 2017). The strategies that teachers obtained from their engagement in the TPD programme were viable and allowed them to effectively leverage IK and address the SDGs.

**6.5 Evaluative analysis related to Research Question Three: To explore the experiences which constrain or enable teachers who seek to address the SDGs by leveraging IK.**

**(a) To explore the factors that obstruct or enable when leveraging IK to address the SDGs in the school curriculum.**

**Theme One: Obstructive Factors**

### **6.5.1 Analysis of Factor One: Time Management**

Nolet (2013) identifies many challenges associated with moving teacher education toward addressing sustainable development. Shava et al. (2020) believe there exists a need for more time directed toward ESD aspects in the school curriculum. These include time-consuming activities like the design and implementation of ESD strategies within CAPS classrooms (Lotz-Sisitka et al., 2017). Sinakou et al. (2018) caution that addressing ESD is a demand that many teachers would not be able to enact. The exercise of addressing ESD in mainstream school curriculums with the existent pressures of curriculum coverage, assessments, and teacher administration would not be easily achievable (UNESCO, 2020).

A study conducted by Cebrián et al. (2015, p. 81) suggests that “although academics might have a personal interest and motivation to engage in ESD, factors such as the lack of time block their engagement in this”. The sustainability agenda has historically failed due to poor time management of sustainability activities (Cebrián et al., 2015).

Stevenson et al. (2017, p. 67) contend that “the lack of time and the reported curriculum opportunities to address sustainable development in the classroom suggest a need for using co-curricular and community initiatives for student investigations and learning”. Stevenson et al.’s (2017) contention are consistent with collaborative engagements, which teachers identified as enabling factors to address ESD. Inadequate time and poor time management can also result in teachers not being able to participate in continuous professional teacher development. The participants in this study were practicing teachers and had to navigate the demands of this PD intervention as well as their curriculum and personal commitments (FN-28/11/2021).

### **6.5.2 Analysis of Factor Two: Lack of Teacher Capacity**

Lotz-Sisitka (2017) argues that curriculum decolonisation using IK is an under-explored concept in sustainable development education, which needs attention. In the SA context, there is a lack of decolonial discourses about marginalized indigenous ideologies in ESD (Lotz-Sisitka, 2017). The limited understanding of decolonising content for ESD by science and mathematics teachers was particularly evident. The lack of knowledge that teachers show is due to the marginalization of indigenous people and their knowledge of formal education systems (Mudaly, 2018a). Cronje (2015) contends that science and mathematics teachers in South Africa lack an understanding of how to leverage IK in their classrooms. This was consistent with Precious' reflections from 01/05/2021 where she stated, "I did not know even where to start because I had no understanding of what was needed".

The CAPS policy, through its principles, requires the inclusion of IK in teaching and learning. However, it fails to give teachers guidelines on how to practically impact epistemological border-crossing (which was explained in Chapter Two, sections 2.23 and 2.24.) in classrooms (De Beer, 2019). Teachers find including indigenous content in the curriculum, a pedagogical cul-de-sac (Opoku & James, 2021). The authors further note that a lack of knowledge of the links between the curriculum and indigenous ideologies is an obstacle to teachers trying to contextualize learning (Opoku & James, 2021). The lack of teacher capacity to teach and understand SD and IK content in the curriculum is an inherent continuation of the systemic challenges teachers had identified in section 5.3.1. Teachers conveyed their lack of capacity in the scarce, vague knowledge they had about SD and IK.

Nordling (2018) acknowledges that science and mathematics departments in SA HEIs have struggled to define what decolonisation through IK means for their curricula. Pitcher and Jones (2018) argue that a lack of educator scholarship on decolonising and Africanising to address current challenges of curriculum development and sustainability is obstructive. The development of teacher agency (discussed below in section 6.6.3) is one way to address the lack of teacher capacity.

## **Theme Two: Enabling Factors**

### **6.5.3 Analysis of Factor One: Democratic Interactions**

The various PD engagements that teachers were exposed to contributed to the discussion on ESD using IK. Hlatshwayo et al. (2020, p. 130) argue that “curricula can be thought of as an active conceptual tool that is dialectical, inclusive, and democratic in its very constitution, capable of enabling varied voices such as those from students, lecturers, policymakers, community stakeholder and others.” Takyi-Amoako and Assié-Lumumba (2018) posit that the practical enactment of the African *ubuntu* paradigm of focusing on collective engagement to achieve SD enables teachers. This paradigm is a unifying force focused on the indigenous agency (Takyi-Amoako & Assié-Lumumba, 2018). This is relevant when considering that SDG 17 speaks to the development and sustainability of “Partnerships for Change” (UNESCO, 2015).

I used a democratic participatory design that is steeped in *Ubuntu-currere* and incorporated SDG 17. The UN (2015, p. 71) explains SDG 17 as “a successful development agenda with inclusive partnerships — at the global, regional, national and local levels — built upon principles and values, and upon a shared vision and shared goals placing people and the planet at the centre”.

### **6.6 Evaluative analysis related to Research Objective Three: (b) To explore how science and mathematics teachers respond to these factors.**

#### **6.6.1 Analysis of Theme One: Expertise of knowledgeable others**

Teachers responded to the obstructive factors of reduced time and lack of capacity, by drawing on the expertise of more knowledgeable others to leverage IK and address the SDGs. One of the main pillars of sustainability is the “social pillar” where the social complexity and its people form a support structure to deal with individual challenges (Eizenberg & Jabareen, 2017). Arora (2018) believes that teachers need to access the support of other experts when faced with challenges in conceptualizing ESD in the classroom context.

Natkin and Kolbe (2016) in their research about sustainability education through curricular reforms report that teachers made progress toward sustainability education by developing a community of experts in different fields who were interested in ESD. Lotz-Sisitka (2017) in her work on the project “Sustainability Begins with Teachers”, argues that a collaborative and supportive environment

fosters the atmosphere to achieve SD. Lotz-Sisitka (2018) advises that it is not the 17 SDGs that change the world but people with political willpower, motives, and resources (human and physical) to share, who change the world. Human resources in this study were people with whom teachers had networked. Material resources were artifacts from IK literature, audio-visual and other teaching aids, textbooks, and learning and teaching support material.

### **6.6.2 Analysis of Theme Two: Teacher Agency**

Teachers also responded to the obstructive factors by developing their teacher agency. Teacher agency was inherently related to teacher learning through consciousness-raising. Le Grange (2021) believes that decolonisation continues to be used by indigenous scholars to refer to correcting the deficit ways in which colonised peoples have been defined and theorized. Smith (1999) believes invoking the histories, indigenous knowledges, and worldviews of colonised people can lead to greater self-determination.

Teachers in this study took the initiative to plan their learning needs and learning strategies, construct their learning goals, determine the material and human resources they require to advance their learning, and evaluate the extent to which the learning outcomes were achieved. Teacher capacity development was made possible by teachers' commitment to acting by engaging in self-directed research as was evident in section 5.4.2.2 d (Teacher learning from self-directed research in Chapter Five). Ekere (2022, p. 12) identifies African people engaging in forms of "self-determination as a decolonisation of the mind and a movement towards reliance on their own indigenous knowledge." Teachers were able to disrupt their colonial value systems which came about through the institutionalisation of western values "which resulted in the entrenchment of mental colonisation, a higher level of colonisation, which is largely responsible for the underdevelopment of Africa in many respects long after direct or physical colonisation" (Ekere, 2022, p. 327).

Hlatshwayo et al. (2020) motivate an emancipatory response to the Euro-Western epistemological canon through a focus on the areas of research and collaboration. These two focus areas as identified by Hlatshwayo et al. (2020) worked harmoniously as response mechanisms. Teachers through their agency, engaged in groups, with IK holders, lecturers, and the researcher to review literature as a response to factors that are obstructive when drawing on IK to address SD in the science and mathematics curriculum. In their quest for an African model of ESD teachers possibly experienced

what Ekere (2022, p. 328) calls, “mental circumcision wherein all or at least most of the colonial vestiges are removed and the people mentally decolonise”.

### **6.6.3 Analysis of Theme Three: Critical engagements**

Lotz-Sisitka (2013, p. 28) believes that “an inclusivity/participatory discourse on educational quality seeks out inclusion in the education system as its measure of quality – for example, the quality of the system is seen to be higher or better if various views are included in pedagogical processes.” The framing of educational quality according to Vygotsky (1978) emphasizes the ‘sociocultural’ or the processes of meaning-making that occur at the interface of existing at the interface between context and concept. This organic meaning-making process within my study emanated from the desire of teachers to seek more critical engagements with stakeholders who were contributing to their PD. The interface between context, which was what IK holders brought, and concept, was what the lecturers and teachers explored within the study of the Honours module.

Bentham et al. (2014) state that teachers should respond to challenges by engaging in participatory and collaborative learning activities within the ESD analytical framework. Science and mathematics teachers learn and improve their teaching pedagogy through focus group discussions and critical group engagements (Dos Santos, 2020). The Three-stage practice-oriented framework for teachers (Kwon et al., 2017) adopted in my study included what Pollard et al. (2014) identify as teachers forming communities with their peers and other experts for extensive engagements. Lotz-Sisitka (2013, p. 31) asserts:

it is necessary to consider the notion of ‘learning as connection’ (meaning: connections to sociocultural, social-ecological, contextual, and historical dynamics of learners’ life-worlds and experiences, and communities’ valued beings and doings) while also giving attention to ‘learning as mastery’ and to ‘learning as participation’ (meaning: individuals having a chance to voice their opinions and express their thoughts in an open, supportive learning environment).

The notion of “learning as connection” is relevant to the deeper engagements that teachers pursued with the “valued beings” in this study. This informed their “learning as mastery” because teachers used these critical engagements to competently decolonise a unit of work from the curriculum by leveraging IK and addressing SDGs. Learning as “communication” and “mastery” was facilitated through the notion of “learning as participation” in keeping with the democratic participatory

research design adopted. Learning as participation was fostered through the “late-night calls to the lecturer”, “FGI engagements”, “conversations with the researcher” and “IK engagements that took place outside the realm of this study or the Honours module”. All of these were initiated by teachers as a response to the engagements they had experienced earlier on in the study.

## **6.7 Discussion of the findings**

At the heart of Agenda 2030 lies the 17 SDGs which serve as goodwill aspirations for all member nations of the UN (UN, 2015). My research focused on the concept of ESD (the educational approach to addressing the SDGs) (UNESCO, 2014). This was engaged with through a decolonial lens where the SDGs were addressed by leveraging IK. My initial findings revealed that teachers addressed the SDGs by leveraging IK in sparse, indirect ways because they received little or no training to teach learners how to achieve the SDGs. Teachers showed little knowledge about how to plan lessons, which are aimed to achieve SDGs, inclusive of IK.

According to Arshad (2020) to decolonise is not about deleting knowledge that has been developed in Euro-Western contexts, rather it is to situate the knowledges that do not originate from the West against the context of imperialism and power and to consider why and how these have been marginalised and de-centered. They developed PoEs, presented decolonised units of work that addressed the SDGs, and participated in FGIs. Teachers re-imagined a decolonial curriculum by committing to the “dreaming” process to leverage IK and address the SDGs in the school curriculum. Teachers however did not stop at Chilisa’s (2012) dreaming stage but moved on to enacting a decolonised curriculum that addressed the SDGs. In doing this they entered a commitment to the action stage “where dreams and commitments translate into strategies for social transformation” (Le Grange, 2016, p. 3). Through Chilisa’s (2012) stages of decolonisation, teachers were able to reposition themselves and IK. This repositioning according to Keval (2019) refers to who and what occupies the centre and the margins of ideas and society and to rebalance that power.

Teachers deconstructed and reconstructed curriculum materials, by conducting CDA of textbooks, curriculum documents, and teaching and learning support material, collaboratively with IK holders. Teachers during the deconstruction stage were able to critique the curriculum and LTSM used for specific units of work. The process of deconstruction offered a foundation for the reconstruction of units of work to occur. Teachers through their PD activities were able to build the knowledge and pedagogical capacity to reconstruct units of work. Findings revealed that teachers committed to

exploring indigenous pedagogic strategies and content from IK. What followed was the enactment of activities underpinned by *Ubuntu-currere* ideology, when they engaged with IK holders to leverage IK towards teaching about sustainable development in the curriculum. These teacher learning experiences lead to teachers raising their critical consciousness to issues of colonization and knowledge production. The various PD activities that teachers engaged in allowed them to develop a decolonial understanding of the curriculum by entering unfamiliar epistemological spaces.

The study demonstrated the potential for transforming the curriculum to become inclusive of “low voices” through what Dasli (2019) calls the production of valuable, truthful, reliable knowledge about living together sustainably. This could be attributed to the commitment shown by teacher groups by (i) engaging with the IK holder, (ii) teacher agency evidenced by extensive self-directed research, and (iii) critically analysing curriculum, textbooks, and support documents. Education for Sustainable Development needs to be conceptualized by South African academics (and teachers) as part of PD programmes at South African higher education institutions. Wang et al. (2020) argue that higher education teaching and learning programmes should be relevant to and aligned with the SDGs, through partnerships with communities, industry, professional bodies, and other organizations which are essential in ensuring that the learning programmes are globally aligned and locally relevant. My study focussed on a specific Honours module by aligning with IK holders from communities by leveraging IK.

I explored how teachers challenge the hegemony of who is seen as a holder of valuable knowledge and what curriculum knowledge is valuable. I worked with teachers, lecturers, and community members in the form of IK holders to leverage theoretical constructs from *Ubuntu-currere* and decolonial theory through the adoption of a decolonial epistemic perspective and privileging dialogic dynamic. The monolithic hegemonic Euro-Western thinking was decentred but not abandoned. Instead, teachers rendered it one part of the intercultural dialogue.

Alex and Juan (2017) note that to attain ESD outlined in the SA National Development Plan 2030, commitment to changing contexts and conditions related to content and pedagogy should be improved. This meant scrutinizing forms of knowledge used to achieve sustainability at an institutional level (Alex & Juan, 2017). This was satisfied through the exploration of how science and mathematics teachers address SDGs by leveraging IK (Objective One of this study). Teachers increase their agency and were able to show a raised consciousness about what was omitted in the curriculum by exploring what Lamont (2018) calls their cultural heritage. Engaging in self-

learning and collaboration with IK holders assisted in this process. In FGI1 teachers alluded to the valourising of scientists from the North as “God(s) of science”.

Teachers that engaged effective TPD processes were able to explore strategies that related to indigenous pedagogy and indigenous content to address the SDGs. Drawing on Chilisa’s stages of decolonisation, teachers also re-imagined and enacted a decolonised curriculum. The further adoption of the Ubunutu-currere allowed teachers to engage collaboratively and challenge the epistemic othering of IK. Through the adoption of the above mentioned strategies, teachers understood their subaltern status fully and were aware that knowledge producers from the “North are positioned as barometers/moderators of true, valid knowledge, making it necessary that whatever that we do we have to pass by them” (Mudaly & Sanjigadu, 2022, p. 22). Teachers understood the intellectual authority (Mignolo 2011) that is attributed to knowledge producers from the North. But they also expressed the need to disrupt this knowledge hierarchy (Mudaly & Sanjigadu, 2022, p. 22).

Teachers developing agency did however experience obstacles to their PD related to decolonising the curriculum. Time management and a lack of capacity to leverage IK to address the SDGs were such obstacles. However, teachers endeavoured to look within themselves and towards each other to help overcome these obstacles. Takyi-Amoako and Assié-Lumumba (2018) explain that teachers are enabled through democratic conversations which strengthen the resolve of teachers who work with curriculum development and re-orientation. There is a consensus in the academy that research and critical reading can build capacity for the improvement of PD related to ESD (Amado et al., 2017). Through their PD, teachers were able to develop an understanding of the SDGs through a decolonial lens (which was based on leveraging IK).

## **6.8 Conclusion**

This chapter offered an evaluative analysis of each identified theme that emerged from this study. I also offered a comprehensive discussion of the findings which emanated. The next chapter (Chapter Seven) will present how I organized this research report and discuss the significant findings, conclusions, recommendations, and theorisation of this study.

## Chapter Seven

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## **7.1 Introduction**

This qualitative study focused on exploring the experiences of science and mathematics teachers in addressing SDGs by leveraging IK. My main focus was to critically explore the pedagogical experiences of science and mathematics teachers who engaged in PD activities as they planned to enact ESD in the SA school curriculum by leveraging IK. I looked at factors that enabled and constrained teachers during this process. This chapter seeks to recapture the emergence of relevant findings from this study as it may inform future decolonial and ESD reforms. I begin by presenting the organization of this dissertation, and then offer a synopsis of the respective findings that emanated. I will then present my theorisation of the findings in the form of a framework that could be used to transform the teacher education curriculum towards Southern relevance and contribute to SD (Cishe, 2017). I subsequently offer a discussion of the recommendations which I direct to science and mathematics teachers, school management teams, curriculum developers, subject advisors, policy developers, IK holders, and society at large. A conclusion brings this chapter and study to a close.

## **7.2 Organization of the report**

This research report was organized into seven (7) chapters. Each chapter focused on a particular stage of the entire research process.

**Table 11**

***Summary of the organization of chapters in the research report***

Chapter number	Overview of chapter
<b>Chapter One</b>	Orientation of study - The first chapter serves as an organizing foundation for the study, it introduced the reader to the context, orientation, aim, and purpose of this study. Furthermore, it gives the reader a quick overview of the research's background and its key concepts. The chapter intended to give the reader a clear understanding of the overall conceptualization and objective of the research endeavor.
<b>Chapter Two</b>	Literature review – This chapter focused the reader on the conceptual basis of this study. I focused this discussion on curriculum conversation, the dimensions of SD, and the links between the basic sciences, IK and ESD.
<b>Chapter Three</b>	Theoretical framework: This chapter focused on the theoretical lenses that informed both my ideological and methodological research approaches. I focused this chapter on currere (curriculum) theory with a focus on the <i>Ubuntu-currere</i> . Furthermore, I discussed the global South lens which I identified as the decolonial theory.
<b>Chapter Four</b>	Research methodology: This chapter detailed the qualitative approach, the critical paradigm, and the research design adopted in this study. I also offer a discussion on the steps in the research, and the use of the FGIs, micro-teaching observations, PoE document analysis, reflections, field notes, and associated instruments used to collect data. In this chapter, I finally presented the ethical considerations such as the use of pseudonyms and processes used to obtain permission and participation for this study.
<b>Chapter Five</b>	Data presentation and Descriptive (Level 1) data analysis: In this chapter, I presented the themes related to each of the three research questions which guided my navigation of this study. The empirical data and a descriptive analysis of the findings were presented.
<b>Chapter Six</b>	Evaluative data analysis and Discussions: Chapter Six offered an in-depth conceptual and theoretical analysis of the data by drawing on the literature presented in Chapter Two and the theories presented in Chapter Three. I concluded this chapter by offering to discuss the main findings of this study.
<b>Chapter Seven</b>	

This chapter concludes the research with a summary of the research findings, theorisation, and proposed recommendations, of this study and implications for further research. This chapter concludes this report and my study.

### **7.3 Summary of Significant findings**

This chapter captures insights from the following three main research questions and supplementary questions:

1. How do science and mathematics teachers address sustainable development goals by leveraging indigenous knowledge?
2. What are the pedagogical experiences of science and mathematics teachers who have engaged in professional development activities in planning to enact the school curriculum by leveraging indigenous knowledge to address the sustainable development goals?
  - (a) What types of strategies do science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address sustainable development goals?
  - (b) Why do science and mathematics teachers who have engaged in professional development activities use the strategies they use?
3. What are the experiences which constrain or enable teachers who seek to address sustainable development goals by leveraging indigenous knowledge?
  - (a) What factors are obstructive or enabling when leveraging indigenous knowledge to address sustainable development goals in the school curriculum?
  - (b) How do science and mathematics teachers respond to these factors?

My study drew rationale from many international, regional, and local agendas, most specifically the SD Agenda 2030 and the global South, decolonial agenda. Agenda 2030 for SD was “strategically deployed to justify the implementation of a highly problematic political project as the framework of global development” (Weber, 2017, p. 2). Lotz-Sisitka (2017) contended for a re-orientation of the PD practices of teachers framed by decolonial thinking for the sustainability of the future.

Research question one was “*How do science and mathematics teachers address SDGs by leveraging IK?*” My study revealed that teachers address SDGs using IK in sparse, indirect ways in the curriculum. This was due to what Mudaly and Ismail (2013) identified as a lack of SD address in TPD programmes in SA. Mudaly and Ismail’s (2013) findings were echoed by teachers in this study. Padayachee et al. (2018) note that issues of SD and sustainability are addressed in isolation and not with IK within the curriculum. Teacher education according to Nolet (2013) has an impact on ESD teaching at school. The absence of effective teacher professional development in sustainable development results in limited teaching of education for sustainable development at schools (Nolet, 2013). Lotz-Sisitka et al. (2021) note that there is a lack of practical examples at teacher education institutes to show how education for SD can be integrated into teacher education. Teachers in my study explained that they had not engaged in PD programmes related to leveraging IK to address the SDGs.

Research question two was “*What are the pedagogical experiences of science and mathematics teachers who have engaged in professional development activities in planning to enact the school curriculum by leveraging indigenous knowledge to address the sustainable development goals?*”. The first sub-question was “(a) What types of strategies do science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address sustainable development goals?” The first type of strategy teachers adopted was to explore indigenous pedagogical and content strategies. Alex and Juan (2017) note that to attain ESD as laid out in the SA National Development Plan 2030, commitment to changing contexts and conditions related to content and pedagogy is important. A change in the way content and pedagogy were presented during micro-teaching presentations and in PoEs was observed. In my study, the colonised were unmuted when their contexts, content, and teaching styles were brought from the margins to the centre. Indigenous knowledge is relevant to sustainable development (Das Gupta, 2011; Kaya, 2013). It is therefore imperative for teacher PD based on SD to include IK (Tikly, 2019).

Teacher then engaged in the re-imagination and enactment of a decolonised curriculum as another strategy to leverage IK and address the SDGs. This involved colonised people (IK holders and teachers) re-imagining an epistemologically alternative curriculum imbued with local IK (Mudaly, 2018a). The action was ideally “strategies for change”, which took the form of a curriculum that reflected the valuing of IK (Mudaly, 2018a), and ESD (Tikly, 2019). Weber (2017, p. 2) posits ESD as the implementation of the global development project at a curriculum level. The dreaming of a

curriculum that focuses on ESD through leveraging IK maintains what, according to UNESCO (2015), is a locally relevant and culturally appropriate, interdisciplinary approach. This re-imagining of a curriculum using different pedagogies that the teachers experienced relates to UNESCO's (2015) ESD focus, which draws on a myriad of pedagogical techniques.

Science and mathematics teachers committed to move from dreaming to engaging in "action" to leverage IK and address the SDGs in the school curriculum. They translated aspirations and thoughts that emanated from dreaming into practical curriculum strategies. Thoughts were linked to re-imagination and learning to incorporate IK and SDGs, planning, and teaching lessons.

Engagement with the IK holders and collaboration through the *Ubuntu-currere* (as discussed in section 5.4.3 in Chapter Five) amongst teachers according to Patton and Parker (2017) reflects teachers' commitment to taking ownership in curriculum implementation. Habermas (2018) argues that action is central to any move toward sustainability.

The third identifiable strategy that teachers adopted was to collaborate and collectively engage as well as challenge the epistemic othering of IK to address the SDGs. Teachers engaged within academic communities (with IK holders) to develop reconstructed models of units of work based on the decentring of Euro-Western epistemologies while recentring of IK and the SDGs as they relate to the South African context (as was observed in the examples from PoEs in Chapter Five). This was done through what Smith (1999) identifies as processes of deconstruction and reconstruction. Deconstruction was based on teachers using CDA to identify, analyse and address colonial remnants in units of work, whereas reconstruction was focused on teachers working with IK holders to include indigenous content, pedagogies, and SDGs into a deconstructed unit of work. Reconstructed units of work can be seen as a decolonial model of ESD. Challenging the hegemonic notion of epistemic othering of IK within *Ubuntu-currere* "disrupts dominant notions of curriculum that predetermine a pathway for pedagogy, through engaging with the complex challenges facing planet earth" (Le Grange, 2019, p. 136). Moloji (2020) believes that decolonial thinkers should draw on various cultures which often differ from the curriculum culture. Challenging the epistemic othering of IK is optimal when coupled with collective engagement and collaboration, as, many role-players bring in a myriad of epistemological and pedagogical views (Le Grange, 2019).

Research question two (b) was "*Why do science and mathematics teachers who have engaged in professional development activities use the strategies they use?*". It was evident that the reason for teachers using the abovementioned strategies was that the strategies obtained from their PD in this

study were effective. Modelling SD practices through PD programmes into curriculum conversations sustains SD (Lebeloane, 2017). Lebeloane (2017) believes that effective PD equips teachers with vital skills to draw on relevant IK and ESD. Kriek and Grayson (2009) note that PD is effective in helping teachers develop adequate curriculum knowledge, teaching approaches, and professional attitudes. Developers of teacher professional development programmes should use demonstrations to effectively transmit good pedagogical practices to teachers (Singh, 2011). Demonstrations of strategies (as shown in Figure 44) of how to leverage IK to address SDGs within the curriculum were presented by lecturers in the Honours module and adopted by teachers.

Research question three was *“What are the experiences which constrain or enable teachers who seek to address sustainable development goals by leveraging indigenous knowledge?”*. The first sub-question of research question three was *“(a) What factors are obstructive or enabling when leveraging indigenous knowledge to address sustainable development goals in the school curriculum?”* Factors that were obstructive were poor “time management” and a lack of “teacher capacity” to leverage IK and address the SDGs. This was consistent with Cebrián et al.’s (2015) and Lotz-Sisitka et al.’s (2017) views.

Cebrián et al. (2015) cite poor time management as an obstructive factor when teachers engage in ESD activities. Whereas Lotz-Sisitka et al. (2017) cite the lack of teacher capacity related to IK knowledge to address SD as a challenge that teachers constantly experience. Jones et al. (2008, p. 347) believe that “a lack of time was unsurprising, named as a significant limiting factor concerning the embedding of ESD in schools”. There were many components of teachers' PD that required time. Attending lectures, meeting in teacher groups, exploring IK, exploring the SDGs, contacting and meeting IK holders, completing PD tasks in the module, presenting units of work, and engaging in reflections and FGIs all depended on effective time management which was obstructive to teachers.

The second factor, lack of teacher capacity was also obstructive. Komatsu et al. (2019) argue that a lack of teacher knowledge about culture and issues of social and environmental conservation are major obstacles to the sustainability project. An analysis of literature supporting ESD, and a sample of its key products suggests that a lack of awareness and acknowledgment of neoliberalism as a hegemonic force blocking transitions towards genuine sustainability remains a challenge on the African continent (Huckle & Wals, 2015).

Factors that were enabling when leveraging IK to address SDGs in the school curriculum were the various democratic interactions that teachers experienced which was a practical enactment of SDG 17- Partnerships for Change. Takyi-Amoako and Assié-Lumumba (2018) believe that democratic conversations strengthen the resolve of teachers who work with curriculum development and re-orientation. Addressing the SDGs through IK in the curriculum is a re-orientation or what Shava et al. (2020) call re-curriculation which was discussed in Chapter Two. The communal engagement between those present, in the learning process (Cormier, 2019), to access and develop sources of knowledge was an important and enabling factor where the creation of reconstructed knowledge was realized. Hlatshwayo et al. (2020) argue that “curricula should not have epistemic closure”.

Research question three, sub-question two (b) was “*How do science and mathematics teachers respond to these factors?*”. Teachers responded differently to the different factors they encountered. To the obstructive factors, teachers responded by drawing on the expertise of more knowledgeable others. Arora (2018) believes that experts are helpful human resources for teachers facing challenges with incorporating IK and addressing SD in the curriculum. Amado et al. (2017) note that an immediate benefit concerning SD, and PDP are the learning and sharing of experiences for best practices from multiple stakeholders. Reade et al. (2013) note that 21<sup>st</sup> Century learning should be based on teachers collaborating with community members in sharing curriculum reconceptualization responsibilities. The teachers, lecturers, IK holders, and I were all stakeholders who contributed toward an understanding of IKS. When faced with challenges, teachers seek network-oriented and stimulated social learning, which promotes interaction and actively encourages and seeks to establish and institutionalize learning networks (Natkin & Kolbe, 2016).

Teachers also responded by developing teacher agency through their PD. Teacher agency in my study was premised on unlearning and re-learning about the curriculum. They unlearned that colonial ideologies are complete truths and re-learned that there is value in IK. Teachers through their agency and self-learning were able to liberate themselves individually and as a collective (through the African collective ideology of *ubuntu*) from the neoliberal, hegemonic notions of education and curriculum development. They deviated from relying solely on the Euro-Western content and pedagogical information present in textbooks and teaching and learning materials, to reading and researching indigenous alternatives. For example, they brought in content information on ‘umqombothi’ and ‘kefir’ and pedagogies like story-telling and indigenous practical demonstrations into a science lesson. Teachers journeyed into intellectual territories that are external to those of the West (Takayama, 2016). They became more familiar with this “new”

intellectual world by engaging in intercultural dialogue (Barreto, 2014), and self-directed research, to learn about a plurality of knowledges (Mudaly, 2018a). Teachers identified different traditional practices that had a common biochemistry like fermentation. By restoring the IK holder as a teacher whose knowledge is worthwhile, teachers were able to rediscover and recover their culture (Chilisa, 2012 as cited in Le Grange, 2016).

Teachers worked with various university and community personnel to engage in PD activities informed by research practices. Through sharing their personal experiences within teacher groups, participants explored decolonisation using the Autobiographical method of curriculum inquiry. This led to a form of self-liberation. Self-determination can invigorate vectors of escape from that which is colonising and through a process of decolonising of the self, the basis could be laid for collective (political and or curriculum) mobilisation (Le Grange, 2021), toward a decolonial and ESD curriculum model. Teacher agency was developed through their self-determination.

Teachers responded to enabling factors by exploring more critical engagements to maximize the skills and knowledge they got from the collaborations with IK holders and lecturers of the Honours module. Teachers extended their participatory discourses through extensive consultations with lecturers and IK holders which Lotz-Sisitka et al. (2017) argue are necessary for the ESD project in Africa. Tikly (2019) believes that within the pan-Africanist understanding, ESD is understood as a vehicle for promoting African cultures and values, which is consistent with the principles of 'SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' (UNESCO, 2017). My study is a higher educational response to the lack of TPD related to addressing the SDGs through leveraging IK, in a uniquely global South context. The theorisation that emanated from the study is presented below.

#### **7.4 Theorisation (Thesis)**

I propose two models (which borrow from theories adopted and presented in Chapters Two and Three) for teacher professional development based on leveraging IK and addressing SDGs in the curriculum. These models are informed by my research findings, analysis, and discussions. Martin and Pirbhai-Illich (2016) suggest that we need to start by looking at what hegemonies dominate the culture and practices of teacher education. Martin and Pirbhai-Illich (2016) also suggest that teacher educators have to become interculturally competent and understand that developing such competencies requires a relational approach that involves developing teacher agency and identity. The models I present can guide teacher educators to be able to foster teacher agency and identity

through PD (in the African context especially). Teachers on the other hand, when engaging in such curriculum development as presented in this study, should ask themselves a key question which is posed by Sathorar and Geduld (2018, p. 14), “who gains and who loses by decolonising the curriculum?”.

My study contributes to a repository of knowledge that shifts its gaze toward a pluralistic form of knowledge for teacher professional development that is inclusive of other epistemologies and education for sustainable development.

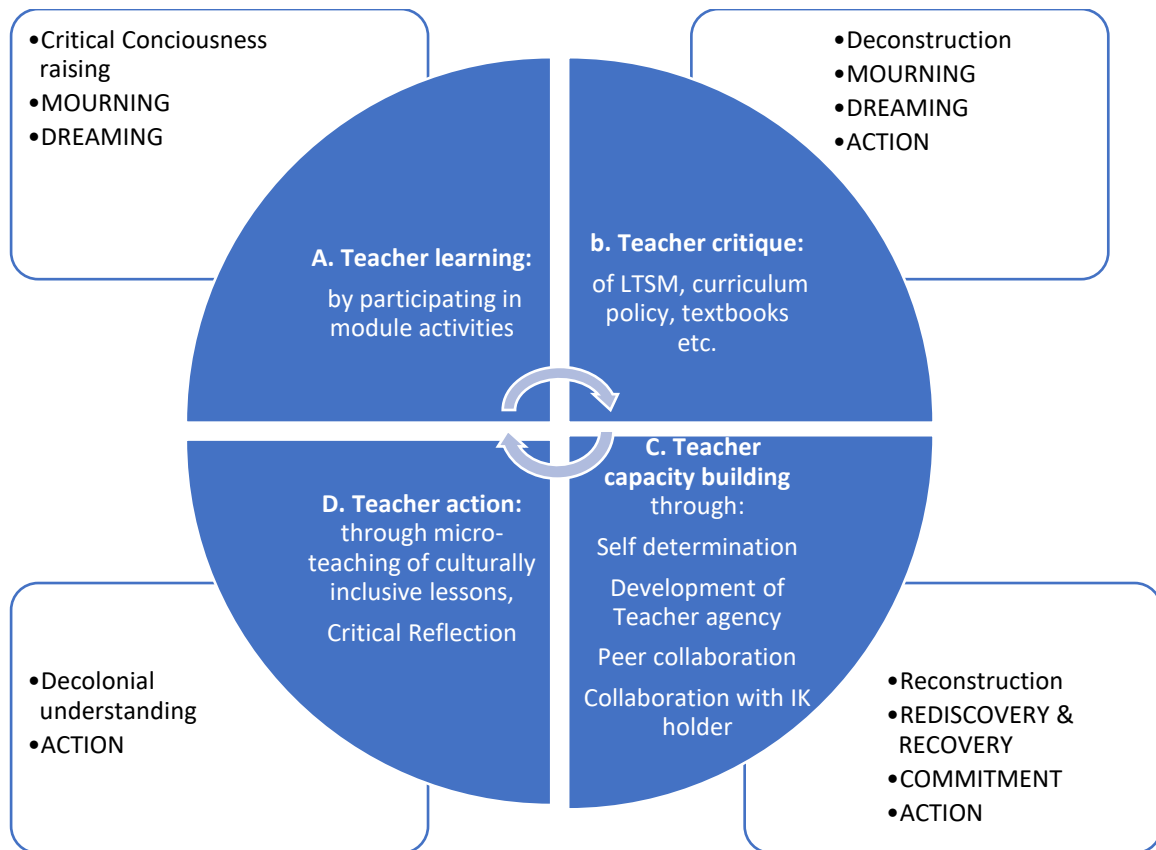
The focus on TPD in this study was based on exploring how teachers decolonise the science and mathematics curriculums using IK to address ESD. This approach to curriculum development and TPD, which draws on global South theoretical constructs like decolonial theory and *Ubuntu-currere* to address SD, is what makes my study new. I bring in IK and “*ubuntu*” in the models I propose because they are consistent with the principles outlined in CAPS, which reflect a uniquely global South, African curriculum context.

#### **7.4.1 The Decolonial Teacher Professional Development (DTPD) model**

The Decolonial Teacher Professional Development (DTPD) model (Figure 45) shows how teacher groups, through democratic teacher-teacher and teacher-teacher-*IK* holder engagements, the notion of ubuntu-ism can contribute to the decolonisation of the curriculum. The model is made up of four interlinking phases (facilitated by underpinning ideologies) which are;

- A. Teacher learning —————> Critical Consciousness raising
- B. Teacher critique —————> Deconstruction
- C. Teacher capacity building —————> Reconstruction
- D. Teacher action —————> Decolonial understanding

There is no specific demarcation among the different phases of each quadrant and the associated processes linked to them. Each phase of the DTPD model informs the other as iterative processes of professional development. For instance, teacher learning informs the type of teacher critique that takes place, and teacher learning is developed from the actions in which teachers engage. Learning informs development which in turn could inform action and vice versa.



**Figure 45: Decolonial Teacher Professional Development (DTPD) Model**

#### 7.4.1.1 Phase A: Teacher learning linked to Critical Consciousness raising

Phase A is based on teacher learning which should be organized toward raising teachers' critical consciousness about the curriculum, epistemological debates, and critical issues related to pedagogy and content. In the context of this study, teacher learning occurred through teachers choosing to study an Honours module (at an HEI). Within an educational setting, teachers began to engage in critical discussions related to the curriculum. By exposing teachers to ideologies related to the decolonial theory they experienced critical consciousness-raising.

For teacher learning to be decolonial and based on the exploration of IK, teachers engaged in Chilisa's (2012) mourning and dreaming stages. These stages not only allow teachers to become aware of the marginalisation of IK but also to re-imagine (dream about) a curriculum where this marginalisation can be redressed. Critical consciousness-raising can be facilitated by mourning the epistemological atrocities of the past which can result in aspirations for an intercultural curriculum model free from the marginalization of IK.

#### **7.4.1.2 Phase B: Teacher Critique Linked to Deconstruction**

Teacher critique (Phase B) is developed through teacher engagement in Phase A. Teachers through their learning develop the competence and courage to begin to critique curriculum policy, textbooks, LTSM, and other support materials which inform their teaching. Teacher critique is facilitated through the process of 'deconstruction'. This phase marks the continuation of mourning and dreaming toward deconstruction. This deconstruction is a practical activity termed 'action' where content, context, and pedagogy described in curriculum policies, textbook extracts, and LTSM are deconstructed. This phase focuses on de Sousa Santos' (2018, p. 115) conception of blurring the "Abyssal line" between those seen as "beings" and those seen as "non-beings" (Maldonado-Torres, 2011) and challenging the power dynamics that exist between global North and global South epistemologies (de Sousa Santos, 2018).

#### **7.4.1.3 Phase C: Teacher Capacity Building Linked to Reconstruction**

The deconstruction phase (Phase B) serves as a basis for teachers to build their competence to decolonise the curriculum. There is a need for teachers to first build capacity before embarking on a curriculum decolonisation endeavour. Teacher development occurs through learning about the decolonisation of the curriculum and the centrality of critique in building teacher capacity. Teacher capacity is also built through teachers collaborating with other teachers and IK holders. In Phase C, teachers can reconstruct units of work in the curriculum by engaging in Chilisa's (2012) stages of rediscovery and recovery, commitment and action, and challenge the epistemic othering of IK. Teachers identify the knowledge that is marginalized in the curriculum and also re-imagine what a decolonial curriculum should look like. At this phase, teachers retrieve (through rediscovery and recovery) knowledge that was marginalized. They then commit to deliberately including these marginalized knowledges through the active reconstruction of units of work in the curriculum.

#### **7.4.1.4 Phase D: Teacher action linked to Decolonial understanding**

Once teachers have developed their capacity to reconstruct units of work, they can take further action by teaching a reconstructed unit of work. This can be done by inviting peers to critique their micro-teaching lessons. This action can lead to a deeper understanding of curriculum decolonisation. Teacher action can also occur through teachers collectively and individually reflecting on their understanding which can then be used to develop further teacher learning (Phase A) in keeping with the iterative nature of the DTPD model. Through critical reflection, teachers can

further explore how to address obstacles such as the lack of time or lack of capacity to decolonise the curriculum. Teachers may also struggle with self and against the colonising effects of a neoliberal order. Since this is a collaborative TPD process teachers can draw on the expertise of other teachers, IK holders, and facilitators for assistance or engage in further research and self-learning to mitigate these challenges.

#### **7.4.2 Decolonial Teacher Development SDGs model**

In the quest to contribute to the knowledge of how TPD could be shaped to capacitate teachers to be able to leverage IK to teach about the SDGs in the science and mathematics curriculum, this study found ways that could be adopted to inform TPD programmes and curriculum developers. The Decolonial Teacher Development SDGs model (Figure 46) I present is informed by the DTPD model (Figure 45 presented above). The Decolonial Teacher Development SDGs model can provide an opportunity for HEIs and teacher education institutions to be able to re-define their TPD programmes which focus on decolonial thinking to address the SDGs.

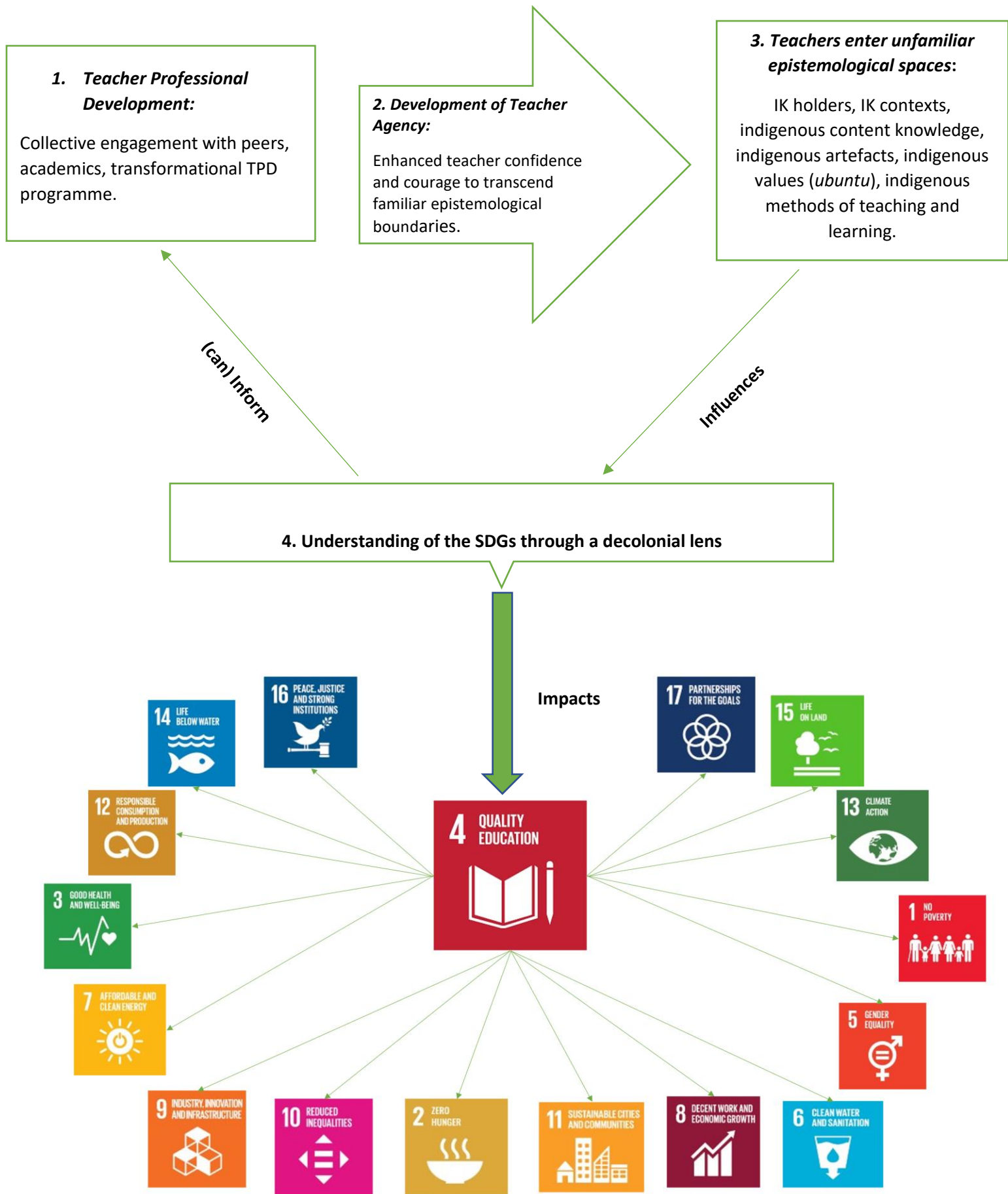


Figure 46: Decolonial Teacher Development SDGs model

The SDGs and ESD as previously discussed in Chapter Two were conceptualized by the UN in 2015 within a Euro-Western (global North) context (Omer, 2020), whereas the understanding of TPD in a SA context should be informed by decolonial scholarship (see Fanon, 1967); Grosfoguel et al., 2015; de Sousa Santos, 2018; Maldonado-Torres, 2011; Ndlovu-Gatsheni, 2018; Chilisa, 2012), and IK ideologies as discussed by Ani (2013), Ndonga et al. (2020), Kaya (2013), Higgs (2012) and Shizha (2017).

The Decolonial Teacher Development SDGs model is made up of phases that work together to address TPD towards SDGs. These phases are;

- Teacher Professional Development
- Development of Teacher Agency
- Teachers enter unfamiliar epistemological spaces
- Decolonial understanding of SDGs

#### **7.4.2.1 Phase 1: Teacher Professional Development**

The teacher professional development phase is linked to the discussions of the DTPD model presented in Section 7.4.1. This phase links to the second recommendation I propose in this chapter (below), whereby HEIs offer TPD programmes focused on valuing IK. The PD that teachers undertake should be facilitated by teacher educators and competent, qualified members of the DBE. In this way, the space, resources, and opportunities for teacher groups to engage in PD will be realized. The TPD offered by HEIs should be driven toward collective engagement (based on the *Ubuntu-currere*) and consciousness-raising. This forms a part of a transformational TPD programme that teachers should experience.

Teacher groups within this phase engage collaboratively through collaboration with IK holders to create collective responsibility in terms of the epistemologies perpetuated in the curriculum. Teachers are not seen as exclusive holders of valuable knowledge. Teachers in collaboration with teacher educators and IK holders redefine the identity of holders of valuable knowledge and what knowledge is seen as valuable and relevant to sustain a specific society. The collective and individual PD processes that teachers undertake offer an ideological and theoretical foundation to explore and critique information present within units of work from the curriculum (Kwon et al., 2017). Teachers may also identify starting points from the curriculum principles from which to teach about

the SDGs (Fundisa for Change Programme, 2013). This could be done through re-imagining and enacting decolonial content and pedagogies.

#### **7.4.2.2 Phase 2: Development of Teacher Agency**

At this phase, teachers through their learning, develop agency. Teachers exercise their agency and freedom from imposed knowledge by taking ownership of their own learning (Madlingozi, 2017). In this way, teachers get to understand themselves in relation to other teachers, people, and the world. The focus is re-centred on ‘the being’ (Maldonado-Torres, 2011). Teachers through their transformational PD processes develop the agency to identify the exclusionary nature of curriculums and the types of knowledges that were pushed to the margins of curriculums. In this phase teachers develop a consciousness about what Paraskeva and Steinberg (2016, p. 203) call curriculum inquiry through “Re-Thinking, decolonising and De-canonizing the Euro-Western epistemological Canon”.

Teacher agency is developed when teachers begin to understand that the curriculum and its associated units of work reflect colonial epistemological dominance (Boisselle, 2016; Heleta, 2016; Mudaly, 2018a; & Raju, 2012). Through this process, there can be enhanced teacher confidence and courage to transcend familiar epistemological boundaries. As much as teacher agency is presented here as a distinct phase, it is an organic process that develops throughout the TPD process. Teachers need to engage in self-learning and self-actualization. Whatever is learnt as a collective can be practiced and internalized by individuals, leading to the decolonisation of the “mind” and the “being” (Maldonado-Torres, 2011). This process is highly driven by constant reading, research, engagement, and the self-actualized desire for knowledge which is based on commitment.

#### **7.4.2.3 Phase 3: Teachers Enter Unfamiliar Epistemological Spaces**

In this study, teachers addressed the SDGs through redeeming of indigenous content and pedagogies which transcend the boundaries of being and non-being, natural and what is seen as unnatural. In Phase 3, teachers develop lesson plans, lessons, and resources to teach content targeted towards addressing various SDGs as set out by the UN (2015), while leveraging IK. Teachers through their PD enter unfamiliar epistemological spaces. They engage in *Ubuntu-currere* ideologies through collaboration and challenging the epistemic othering of IK (Le Grange, 2019). Teachers learn about the various dimensions that can assist them in engaging in epistemological

border-crossing. They become aware of the role of IK contexts, indigenous content knowledge, indigenous artifacts, indigenous values (*ubuntu*), and indigenous methods of teaching and learning. Teachers search for indigenous ideas and knowledge by engaging with IK holders and in research (Re-discovery and Recovery).

The process of re-centring of IK directly challenges the Euro-Western hegemonic notion of placing IK in the category of “the other” (Maldonado-Torres, 2011). This process involves teachers engaging in critical pedagogy and deconstruction of initial units of work to reconstruct and reflect a decolonial unit of work that is socially just.

#### **7.4.2.4 Phase 4: Understanding of the SDGs Through a Decolonial Lens**

Teachers' PD and the development of their agency allow teachers to enter unfamiliar epistemological spaces and thus influence their understanding of decolonisation and the curriculum. This process can lead to an inherent conception of ESD in units of work within the CAPS curriculum in the SA context and other similar global South contexts.

Teacher groups conceptualize units of work by journeying from the epistemic territory of the North, towards that of the South. Through this epistemic journeying, teachers can enter a third space (Le Grange, 2019). To do this teachers' capacity and confidence are enhanced through collective engagements (with module lecturers, their peers, and IK holders) and through self-learning. They overcome obstacles and embrace the enablers of their PD.

Teachers through their development as per the “Decolonial Teacher Development SDGs model” (Figure 46) can become competent curriculum developers able to understand opportunities to include IK and address the SDGs within units of work. The epistemic border-crossing not only occurs between IK (South) and Euro-Western knowledge but also between the aforementioned forms of knowledge and ESD principles and values. A renewed approach to designing units of work reconstructed from the science or mathematics curriculum through the use of indigenous content and pedagogy is realized through this phase. These new units reflect leveraging of IK to address the SD issues which impact the economic, social, and environmental dimensions and lead to a form of ESD within the curriculum. Teacher groups understand and develop units of work that include activities and tasks which are targeted toward valuing IK and addressing the SDGs.

#### 7.4.2.5 Addressing the SDG

The process of conceptualizing ESD in a SA context makes it possible to teach about the 17 SDGs within specific units of work from the science and mathematics CAPS curriculum. Although the SDGs are defined by the UN, they perpetuate universal sustainability values to which all citizens of the world should aspire. (UN, 2015). Teachers who learn about addressing SDGs can increase awareness of members of society (the social pillar of sustainability) of the SDGs. The impact that these trained people can have on all three pillars of sustainability and future generations cannot be underestimated. Teachers who engage in a professional development programme using a decolonial lens can develop an understanding of the SDGs that is contextually relevant. This will contribute directly to 'SDG 4: Quality Education' by offering a culturally relevant, contextually inclusive form of teaching. Education is a basic right and elementary to human dignity. Sustainable Development Goal 4 has reciprocal linkages across the 2030 Agenda (UN, 2015). Access to quality education is an avenue for social mobility and reducing inequalities, it is essential for building the knowledge base we need to tackle critical challenges like climate change and inequality (UNESCO, 2020). It is imperative to understand the vitality of SDG 4, as it is a preamble to becoming aware of the 16 other SDGs (Tikly, 2019). The UN (2015) notes that there are several education-related targets and indicators in other SDGs, including health and well-being (Target 3.7), gender equality (Target 5.6), decent work (Target 8.6), responsible consumption and growth (Target 12.8), and climate change mitigation (Target 13.3). If learners are taught based on the indicators of SDG 4, teachers would succeed in:

promoting sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all (SDG 8) be able to teach about resilient infrastructure, promote inclusive and sustainable industrialization, and fostering innovation (SDG 9), ensure Ensure sustainable consumption and production patterns (SDG 12) and strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development (SDG 17) (UN, 2015).

Once learners complete their basic schooling, they either go into the industry as workers, or higher education institutions, become entrepreneurs and/or farmers, or become unemployed. Contextual knowledge of the SDGs may allow learners to become members of society who directly address the SDGs that are related to employment, production, and consumption. The same members of society will be able to care for the life on land, under water and consume energy responsibly which will address SDGs 6 (Clean water and Sanitation), 7 (Affordable and clean energy), 14 (Life Below water), and 15 (Life on land) as shown in Figure 47. Understanding and enacting quality and

inclusive education (SDG 4) premised on social responsibility negotiated with society will lead to the achievement of all other SDGs. This form of education could:

- SDG 1: End poverty in all its forms everywhere.
- SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- SDG 3: Ensure healthy lives and promote well-being for all at all ages
- SDG 5: Achieve gender equality and empower all women and girls
- SDG 6: Ensure availability and sustainable management of water and sanitation for all.
- SDG 10: Reduce inequality within and among countries.
- SDG 11: Make cities and human settlements inclusive, safe, resilient, and sustainable.
- SDG 13: Take urgent action to combat climate change and its impacts.
- SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels (UN, 2015), is addressed in specific contexts.

A detailed, contextual understanding of SDG 4 will lead to the achievement of all other SDGs. In the SA context, teachers' understanding of the SDGs through a decolonial lens will allow for the achievement of all SDGs.

The models I propose in Figures 45 and 46 can be adopted to develop TPD to address the lack of locally relevant SD contributions set out in Agenda 2030 (Lotz-Sisitka et al., 2017). This model with its associated phases and the process can guide teacher educators, the DBE, and HEIs to integrate SD into teacher education which Lotz-Sisitka et al. (2017) identify as a need. Learnings from my study offer a contextual and methodological framework for TPD for teachers to become interculturally competent and confident in dealing with particularly issues related to decolonisation and sustainable development.

## **7.5 Recommendations**

### **7.5.1 Recommendation one: Teachers to form multi-stakeholder collegial networks to improve ESD in the African context (*Ubuntu*)**

My study revealed a need for teachers to form collegial networks with other teachers, members of society, and especially IK holders who dedicate themselves to the improvement of ESD in a uniquely African context. A combination of different people from different socializations, having different knowledge and skill sets, who work collectively, is recommended. There is a need for all individuals in society to collaboratively invest in ESD. This recommendation is premised on the creation of communities of practice (CoPs) or professional learning communities (PLCs) as active bodies within education institutions and society at large to aid in developing ESD. Community leaders, academics, and influential members of society should all join teachers to create collegial forums where discussion and relevant ESD curriculum planning processes are centred. Science and mathematics teachers who learn from one another and other members of society will be better equipped to teach in a way that values AIK and addresses SD.

### **7.5.2 Recommendation Two: Higher Education Institutions to offer TPD programmes focused on ESD through valuing IK**

Scholarship based on decolonial emancipatory pedagogies like valuing IK and addressing SD within global South HEIs in the post-pandemic era is necessary. It is recommended that teacher educators and institutions explore avenues to offer TPD focused on education for the future and ESD. This could improve teachers' and academics' interest and motivation to engage in ESD. The transformation and decolonisation agendas at universities should be systems-oriented toward training teachers about sustainability issues. The SDGs could be locally adapted and included in TPD programmes to suit the contexts of the learners in society. In order for the UN (2015) Agenda on ESD to be understood as empowering and not oppressive, it should be easily adaptable to geographies, epistemologies, and biographies in Africa and the global South in general. Teachers who are central to this process, therefore, need to be trained accordingly. I recommend a more focused programme modelled on, for example, the Fundisa for Change programme in SA. The Fundisa for change Programme is a multi-stakeholder collaborative national professional learning community established as a South African community of practice response towards enhancing and supporting transformative environmental and sustainability learning through teacher education in the country (Fundisa for Change Programme, 2021). During the year 2020, Fundisa for Change materials were adapted to include IK content and contexts of indigenous people.

### **7.5.3 Recommendation Three: Including IK holders in TPD programmes that focus on ESD**

There is a need to consciously involve IK holders in the development of teaching and learning materials, and in-service and pre-service teacher training programmes. This is crucial to de-centre the Euro-Western framework that currently dominates the curriculum. To neutralize what Keane et al. (2017, p. 13) term “the largely Western–English–academic hegemony usually assumed (through a careful gate-keeping process) that only certain knowledge is validated”, there is a need for IK holders to be engaged.

My study recommends that IK holders become involved in PD programmes which include but are not limited to, pre-service teacher training, workshops, and in-service teacher training programmes to develop teachers’ and curriculum developers’ capacity to include IK in education. Organizations such as DSI-NRF Centre in Indigenous Knowledge Systems (2021) believe that IK holders and practitioners are the custodians of IKS. This implies that IK holders should be recognized as active participants in and not mere objects of the research process (DSI-NRF Centre in Indigenous Knowledge Systems, 2021). Programmes like Fundisa for Change could be structured to offer IK holders a more active (knowledge and skills sharing) role.

There needs to be a discussion on how the curriculum can be decolonised through leveraging IK. Indigenous knowledge introduced to the curriculum should be relevant to significant learning (as discussed in Chapter Two) in the curriculum and monitored by IK holders, curriculum developers, and teachers. In this way, the inclusion of sustainable indigenous practices and concepts can be introduced seamlessly into basic science subjects, as well as other subjects.

### **7.5.4 Recommendation Four: Teachers to inculcate the valuing of IK and sustainable development within all subjects in the SA curriculum**

The final recommendation is proposed in collaboration with teachers in this study. In keeping with the democratic identity through the research paradigm adopted, recommendations made by teachers were as valuable as the previous recommendations I offered. Teachers believed that there is a need for all subjects to become organically positioned to encompass local models of ESD. South African teachers should approach pedagogies from a critical standpoint placing sustainability, decolonisation, and significant learning like “care and Ubuntu-ism” at the centre of their teaching (Shumba et al., 2020).

Cat in her recommendation on subjects that could allow for IK to be leveraged and address the SDGs (which was asked in FGI2-Q21) noted that “...is so ideal for Geography because there are so many aspects in “Poverty, Equality, in Water, in Recycling”, in everything” (FGI2-Q21). Will concurred with this recommendation when he said “...I think it can be used in all subjects, the languages, the humanities, and the sciences because sustainable development is something that we should all be concerned about in all spheres of life” (FGI2-Q21). Sbu identified and recommended a topic through which decolonial and sustainable thinking would come alive. He said, “...Economic Management Science. This can link to Sustainable Infrastructure and Sustainable Economies” (FGI2-Q21). His views are directly linked to SDG 8: Decent work and economic growth and SDG 9: Industry, Innovation, and Infrastructure. Sbu’s ability to make these connections speaks to the depth of knowledge that teachers were exposed to during their professional development. They were able to make links between curriculum topics and SDGs.

Another recommendation is for teachers of all subjects to engage in reflective PD focused on education that addresses the many SD challenges that learners in SA will experience. The post-colonial, post-COVID, 4IR global condition requires teachers to be able to prepare learners for an unknown, rapidly changing future. Teachers should embrace alternative approaches while building conceptual bridges among IK, Euro-Western knowledge, and ESD. This should be done by de-constructing oppressive Northern epistemologies and re-constructing them using Southern (global) epistemologies.

## **7.6 Implications for further research**

There is a paucity of research on “how” teachers of all subjects can engage in PD using a decolonial approach to address societal, economic, and environmental issues in the global South. Further studies in the decolonisation of science, mathematics, and other subjects in the curriculum to reflect ESD are important. Scholarship that focuses on ways to decolonise units of work in addition to using IK to address SD is imperative if SA is to address the sustainability challenges it faces. Challenges include COVID-19, load-shedding (interrupted supply of water and electricity), the aftermath of state capture, the impact of the July 2021 riots (which took place in the South African provinces of Gauteng and Kwa-Zulu Natal), and the aftermath of the April-May 2022 floods (in KwaZulu- Natal) as well as other societal ills (poverty, unemployment, lack of health care and crime). These societal challenges may be resolved completely or partially if the SDGs and underlying principles of SD are addressed. For example, valuing the need for and societal address of SDG 6 which is based on “ensuring availability and sustainable management of water and sanitation for all” (UN, 2015) could have limited the water cuts experienced in the Eastern Cape

(Nelson Mandela Bay municipality) and the KwaZulu- Natal provinces in the year 2022. Valuing and achieving the principles of SDG 7 which is based on “ensuring access to affordable, reliable, sustainable and modern energy for all” would lessen load-shedding and the Eskom energy crisis experienced in SA over the last 10 years. Education reforms are necessary for societal change (UN, 2015).

De Sousa Santos (2018, p. 152) believes that there is a need to retrieve “the suppressed, silenced and marginalized knowledge through engaging in “sociology of absences” which is a procedure showing that agents on the South side of the abyssal line are actively engaging in resistance against dominant ways of knowing”. This expands into a need for further critical explorations into how the curriculum, as a whole, can be decolonised while addressing SD. The model I propose (Figure 46) can serve as a conceptual foundation on which further research on addressing SD through indigenous ideologies can be developed.

## **7.7 Conclusion**

In working towards a decolonial epistemic politic, I examined how science and mathematics teachers adopted *Ubuntu-currere* by dreaming about and actioning indigenous content and pedagogy to address SD while working towards decolonising the curriculum. Teachers engaged in intercultural dialogue and teacher agency to dream about possibilities for creating relevant units of work that could challenge the othering of IK and retrieving relevant IK which had historically been pushed to the margins of formal education programmes. By restoring the IK holder as a teacher whose knowledge is worthwhile, teachers were able to rediscover and recover their own culture (Le Grange, 2016), and re-imagine and enact an alternative curriculum that recentres IK and knowledge for SD. The methodology in this study was transformative because it privileged the idea of linking teachers and learners with IK holders and other members of society who can be positioned as repositories of useful knowledge. In this way, the decolonial approach to teaching allows for a repainting of the curriculum canvass and recasting curriculum actors to participate democratically in a sustainable more-than-human world.

This chapter presented the organization of this report, a summary of the main research findings, and proposed research recommendations that emanated from my study. The recommendations resonate with theoretical constructs from the *Ubuntu-currere* as well as the decolonisation process as advocated by Chilisa (2012). The proposed recommendations from this study are directed to teachers, teacher educators, school managers, community members, IK holders, policy developers, curriculum designers, and department officials. This chapter also offered the thesis of

this study and my contribution to the body of knowledge in curriculum development for social transformation in the form of the “Decolonial TPD model of ESD”. This model can be actively adapted and include characteristics with which teacher groups and learners identify. (Bernier, 2018). Gorman (2015) proposes we think the redesign of educational models that leverage students and their communities as resources. Addressing ESD through decolonisation of the curriculum presents a new model approach to education (Clingan, 2015). My proposed model suits the global South context and can inform future decolonial ESD programmes, teacher educators, and HE curriculum developers of the importance of leveraging IK to address the SDGs in the curriculum.

It can be argued that my focus on SDGs (paradoxically) favours what Singh (2020) refers to as the more affluent, technologically advanced, and better-resourced global North. The 2030 Agenda for SD has been embraced globally, regardless of its geopolitical position. Adopting SDGs as a focus of the curriculum was suitable to explore possibilities for what de Sousa Santos (2018) calls post-abysal thinking. Teachers journeyed into intellectual territories that were outside of the West (Takayama, 2016). They became more familiar with a “new” intellectual world by engaging in intercultural dialogue (Barreto, 2014), and developing their agency through learning and research, to learn about a plurality of knowledges (Mudaly, 2018a) through epistemological border-crossing between AIK and colonial knowledge as well as ESD and basic science knowledge. Individuals (teachers) were able to re-enter the present with a “renewed sense of self, able to see the wholeness of past, present, and future, and ask what does this mean and what can I do?” (Le Grange, 2021, p. 11). Through self-determination, decolonisation becomes a struggle to rid the self (individual and collective) of the fetters of coloniality (Le Grange, 2021). Teachers identified different traditional practices that had common biochemistry, like fermentation. They assured the quality of the curriculum unit by engaging with IK holders to review units of work. In this way, they adopted the “low voices” (IK holders) as a barometer of valuable knowledge.

## References

- Abah, J., Mashebe, P., & Denuga, D. D. (2015). Prospect of integrating African indigenous knowledge systems into the teaching of sciences in Africa. *American Journal of Educational Research*, 3(6), 668-673.
- Abawi, K. (2013). *Data Collection Instruments (Questionnaire & Interview)*. Geneva: Geneva Foundation for Medical Education and Research. Retrieved from <http://www.gfmer.ch/SRH-Course-2012/Geneva-Workshop/pdf/Data-collection-instruments-Abawi-2013.pdf>.
- African Union. (2015). Agenda 2063: The Africa We Want. *African Union Commission*. <https://au.int/en/agenda2063/overview>.
- Agbedahin, A. V. (2019). Sustainable development, Education for Sustainable Development, and the 2030 Agenda for Sustainable Development: Emergence, efficacy, eminence, and future. *Sustainable Development*, 27(4), 669-680.
- Ahmed, A. K. (2020). *Decolonising the vaccine*, The Elephant. Accessed at [www.theelephant.info/op-eds/2020/07/17/decolonising-the-vaccine/](http://www.theelephant.info/op-eds/2020/07/17/decolonising-the-vaccine/)
- Akala, B. M. (2018). Challenging gender equality in South African transformation policies—a case of the white paper: a programme for the transformation of higher education. *South African Journal of Higher Education*, 32(3), 226-248.
- Alenaizi, H. M. (2018). Doing Participatory Research with Disabled People in Kuwait. *Disability Studies Quarterly*, 38(2) 12-22.
- Alex, J. K., & Juan, A. (2017). Quality education for sustainable development: Are we on the right track? Evidence from the TIMSS 2015 study in South Africa. *Perspectives in Education*, 35(2), 1-15.
- Alfred, T. (2009). Colonialism and state dependency. *Journal of Aboriginal Health*, 5, 42–60.
- Allen, A. (2016). *The end of progress: Decolonising the normative foundations of critical theory* (Vol. 36). Columbia University Press.
- Amado, A., Dalelo, A., Adomßent, M., & Fischer, D. (2017). Engaging teacher educators with the sustainability agenda: A case study of a pilot professional development program from Ethiopia. *International Journal of Sustainability in Higher Education*, 18(5), 715-737.
- Amanor, K. S., & Moyo, S. (2013). *Land and sustainable development in Africa* (pp. 34-37). Zed Books Ltd.
- Anderson, E. (2012). Epistemic justice as a virtue of social institutions. *Social Epistemology*,

26(2), 163-173.

- Ani, N. C. (2013). Appraisal of African epistemology in the global system. *Alternation*, 20(1), 295-320.
- Annan-Diab, F., & Molinari, C. (2017). Interdisciplinarity: Practical approach to advancing education for sustainability and for the Sustainable Development Goals. *The International Journal of Management Education*, 15(2), 73-83.
- Apple, M. W. (2019). On doing critical policy analysis. *Educational Policy*, 33(1), 276-287.
- Arora, N. K. (2018). Environmental Sustainability—necessary for survival. *Environmental Sustainability*, 1(1), 1–2.
- Arshad, R. (2020). Lessons learnt about ‘race’ in Scotland. *Taking Stock: Race equality in Scotland*, 8-10.
- Asghar, J. (2013). Critical Paradigm: A Preamble for Novice Researchers. *Life Science Journal*, 10(40), 3123-3127.
- Azzarri, C., & Signorelli, S. (2020). Climate and poverty in Africa South of the Sahara. *World development*, 125, 104691.
- Ba, O. (2017). International justice and the postcolonial condition. *Africa Today*, 63(4), 45-62.
- Balfour, R. J. (2015). *Education in a New South Africa*. Cambridge University Press.
- Bamber, P., Bullivant, A., Glover, A., King, B., & McCann, G. (2016). A comparative review of policy and practice for education for sustainable development/education for global citizenship (ESD/GC) in teacher education across the four nations of the UK. *Management in Education*, 30(3), 112-120.
- Barnhardt, N. R. (2014). Creating a place for indigenous knowledge in education: The Alaska native knowledge network. In *Place-based education in the global*. Routledge.
- Barreto, J. M. (2014). Epistemologies of the South and human rights: Santos and the quest for global and cognitive justice. *Ind. J. Global Legal Stud.*, 21, 395.
- Barsan, G., Nastasescu, V., & Barsan, V. (2011). Education for Sustainability implementation in knowledge-based organizations. *Revista Academiei Fortelor Terestre*, 3(63), 283-286.
- Bartniczak, B., & Raszkowski, A. (2019). Sustainable Development in African Countries: An Indicator-Based Approach and Recommendations for the Future. *Sustainability*, 11(1), 22.
- Barton, E., Bates, E. A., & O'Donovan, R. (2019). ‘That extra sparkle’: students’ experiences of volunteering and the impact on satisfaction and employability in higher

- education. *Journal of Further and Higher Education*, 43(4), 453-466.
- Bentham, H., Sinnes, A. T., & Gjøtterud, S. (2014). Exploring the priorities of teacher education related policies: An education for sustainable development perspective. *Journal for Critical Education Policy Studies*, 12(1), 321–360.
- Bernier, A. (2015). *Designing a Systems Based Curriculum to Develop 21st Century Sustainability Literacy and Communication Skills*. Ph.D. Thesis, Prescott College, Prescott.
- Bernier, A. (2017). From Linear Industrial Structures to Living Systems: A Design Shift in Education for Sustainability. *Education Sciences*, 7(2), 43. Retrieved from <http://dx.doi.org/10.3390/educsci7020043>
- Bernier, A. (2018). How Matching Systems Thinking with Critical Pedagogy May Help Resist the Industrialization of Sustainability Education. *Journal of Sustainability Education*, 18(1), 22-36.
- Bezuidenhout, W., Clark, A., Doubell, S., Engelbrecht, A., & Viljoen Cloete, A. (2012). Oxford Successful Life Sciences Grade 11 Learner's Book 3e (CAPS). *Oxford University Press*.
- Biko, S. (1977). Black consciousness and the quest for a true humanity. *Ufahamu*, 8(3), 10-20.
- Biros, M. (2018). Capacity, vulnerability, and informed consent for research. *The Journal of law, Medicine & Ethics*, 46(1), 72-78.
- Blewitt, J. (2018). *Understanding sustainable development* (3rd ed.). Routledge.
- Boateng, O. (2013). Why our future should be made in Africa. *New African*, 528, 8-9.
- Bob, U., Munien, S., Gumede, A., & Gounden, R. (2020). Supporting Research at Universities during the COVID-19 Crisis: Key Areas for Consideration and Critical Reflections on Responses with a Focus on Postgraduate Education. *Alternation*, 1(1) 2-3.
- Boisselle, L. N. (2016). Decolonising science and science education in a postcolonial space (Trinidad, a developing Caribbean nation, illustrates), Sage Open.
- Bowen, G. A. (2017). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, 9, 27-40.
- Breems, B. (2016). Relational Being as Icon or Communal Freedom: Southern Africa's Ubuntu. *Journal of Sociology and Christianity*, 6(2).
- Breidlid, A. (2013). *Education, indigenous knowledges, and development in the global south: Contesting knowledges for a sustainable future* (Vol. 82). Routledge.
- Brinkmann, S., & Kvale, S. (2018). *Doing interviews* (Vol. 2). Sage.
- Bulhan, H. A. (2015). Stages of colonialism in Africa: From occupation of land to occupation of being. *Journal of Social and Political Psychology*, 3(1).

- Cable News Network. (2022). How new green projects are curbing emissions in South Africa. Marketplace Africa. Accessed at [How new green projects are curbing emissions in South Africa \(cnn.com\)](https://www.cnn.com).
- Catala, A. (2015). Democracy, trust, and epistemic justice. *The Monist*, 98(4), 424-440.
- Cebrián, G., Grace, M., & Humphris, D. (2015). Academic staff engagement in education for sustainable development. *Journal of Cleaner Production*, 106, 79-86.
- Césaire, A. J. (2000). *Discourse on Colonialism*, New York: Monthly Review Press.
- Chilisa, B. (2012). *Indigenous research methodologies*, CA: Sage Books.
- Christie, P. (2020). *Decolonising Schools in South Africa: The Impossible Dream?* Routledge.
- Christie, P., & McKinney, C. (2017). Decoloniality and "Model C" schools: Ethos, language and the protests of 2016. *Education as Change*, 21(3), 1-21.
- Cilliers, J. (2008). In search of meaning between Ubuntu and Into: Perspectives on preaching in post-apartheid South Africa. *Paper delivered at the eighth international conference of Societas Homiletica*, held in Copenhagen, Denmark, 19-25 July 2008.
- Cishe, E. N. (2017). Teachers' perspectives on transforming teacher education curriculum for relevance to basic education for sustainable development. *Perspectives in Education*, 35(2), 73-84.
- Clayton, T., & Radcliffe, N. (2018). *Sustainability: a systems approach*. Routledge.
- Clingan, J. (2015). A Pedagogy of Love. *In Journal of Sustainability Education*, 9(1), 6-7. Retrieved from <http://www.jsedimensions.org/>
- Cobbinah, P. B., & Darkwah, R. M. (2017). Toward a more desirable form of sustainable urban development in Africa. *African geographical review*, 36(3), 262-285.
- Cobbinah, P. B., Erdiaw-Kwasie, M. O., & Amoateng, P. (2015a). Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environmental Development*, 13, 18-32.
- Cobbinah, P. B., Erdiaw-Kwasie, M. O., & Amoateng, P. (2015b). Africa's urbanisation: Implications for sustainable development. *Cities*, 47, 62-72.
- Cohen, L., Manion, L., & Morrison, K. (2017). *Research Methods in Education*, (8th edition). Routledge.
- Colebrook, C. (2014). *Death of the PostHuman: Essays on Extinction*, vol. 1 (p. 249). Open Humanities Press.
- Colglazier, W. (2015). Sustainable development agenda: 2030. *Science*, 349(6252), 1048-1050.
- Comaroff, J., & Comaroff, J. L. (2012). *Theory from the South: Or, how Euro-America is evolving*

- toward Africa. In *Anthropological forum*, Routledge.
- Cope, D. G. (2014). Methods and meanings: credibility and trustworthiness of qualitative research. In *Oncology nursing forum*, 41(1), 27 -32.
- Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.
- Cormier, D. (2019). *Rhizomatic Education*. EdTech in the Wild. <http://www.innovateonline.info/index.php?view=article&id=550>
- Corntassel, J. (2012). Re-envisioning resurgence: Indigenous pathways to decolonisation and sustainable self-determination. *Decolonisation: Indigeneity, Education & Society*, 1(1), 86–101.
- Costanza, R., Fioramonti, L., & Kubiszewski, I. (2016). The UN Sustainable Development Goals and the dynamics of well-being. *Frontiers in Ecology and the Environment*, 14(2), 59-59.
- Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. (4th Ed.). Boston: Pearson.
- Creswell, J. W. (2014). *Research Design Qualitative, Quantitative and Mixed Methods Approaches (4<sup>th</sup> ed.)*. Research Approaches, Sage publications.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.
- 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*. 15-18.
- Cumbo, B., & Selwyn, N. (2022). Using participatory design approaches in educational research. *International Journal of Research & Method in Education*, 45(1), 60-72.
- Cumming, T. L., Shackleton, R. T., Förster, J., Dini, J., Khan, A., Gumula, M., & Kubiszewski, I. (2017). Achieving the national development agenda and the Sustainable Development Goals (SDGs) through investment in ecological infrastructure: A case study of South Africa. *Ecosystem services*, 27, 253-260.
- Cusicanqui, S. R. (2012). Ch'ixinakax utxiwa: A Reflection on the Practices and Discourses of Decolonisation. *South Atlantic Quarterly*, 111(1), 95-109.
- Dani, S., & Shah, S. (2016). Call and definition of rural university. *IOSR Journal of Economics and Finance*, 7(1), 64-66.

- Daniel, I., Ferendinos, J., Iyer, N., & Harber, R. (2022). Decolonial Thinking and Practice. *Journal of the KwaZulu-Natal Region of the South African Institute of Architects*, 47(2),1-16.
- Dasli, M. (2019). UNESCO guidelines on intercultural education: a deconstructive reading. *Pedagogy, Culture & Society*, 27(2), 215-232.
- Das Gupta, A. (2011). Does Indigenous Knowledge have anything to deal with Sustainable Development? *Antrocom Online Journal of Anthropology*, 7(1) 63.
- Dastile, N. P., & Ndlovu-Gatsheni, S. J. (2013). Power, knowledge and being: Decolonial combative discourse as a survival kit for Pan-Africanists in the 21<sup>st</sup> century. *Alternation* 20(1), 105-134.
- David, A., Guilbert, N., Hamaguchi, N., Higashi, Y., Hiroyuki, H., Leibbrandt, M., & Shifa, M. (2018). *Spatial poverty and inequality in South Africa: A municipality level analysis* (No. 221). Southern Africa Labour and Development Research Unit, University of Cape Town.
- Davids, M. N. (2018). Ideology critique as decolonising pedagogy: Urban forced removals as a case study. *Educational Research for Social Change*, 7 (spe.), 16-30.
- Davis, A. Y. (2016). *Freedom is a constant struggle: Ferguson, Palestine, and the foundations of a movement*. Haymarket Books.
- De Beer, J. (2019). The decolonisation of the curriculum project: The affordances of indigenous knowledge for self-directed learning', in NWU Self-directed Learning AOSIS, Cape Town.
- de Beer, J., & Petersen, N. (2016). Decolonisation of the Science curriculum: A different perspective (#Cookbook-Labs-Must-Fall). *Proceedings from ISTE International Conference on Mathematics, Science and Technology Education: Towards Effective Teaching and Meaningful Learning in Mathematics, Science and Technology*. Retrieved from <http://hdl.handle.net/10500/22869>
- Deleegn, A., Sahile, S., & Husen, A. (2018). Water purification and antibacterial efficacy of *Moringa oleifera* Lam. *Agriculture & Food Security*, 7(1), 1-10.
- Dempsey, N., Brown, C., & Bramley, G. (2012). The key to sustainable urban development in UK cities? The influence of density on social sustainability. *Progress in planning*, 77(3), 89-141.
- Denzin, N. K., & Lincoln, Y. S. (Eds.). (2018). *The Sage handbook of qualitative research*. Sage.
- Department of Basic Education. (2011). *Curriculum and Assessment Policy Statement:*

- Sciences and Mathematics*. Pretoria. Retrieved from <http://www.dbe.kzn.gov.za>.
- de Sousa Santos, B. (2018). *The end of the cognitive empire: The coming of age of epistemologies of the South*. Duke University Press.
- de Sousa Santos, B. (2015). *Epistemologies of the South: Justice against epistemicide*. Routledge.
- Dewey, J. (1916). *Democracy and education*. New York: Macmillan.
- Dong, Y., & Hauschild, M. Z. (2017). Indicators for environmental sustainability. *Procedia Cirp*, 61, 697-702.
- Doody, O., & Doody, C. M. (2015). Conducting a pilot study: Case study of a novice researcher. *British Journal of Nursing*, 24(21), 1074-1078.
- Dos Santos, L. M. (2020). Pre-service teachers' pedagogical development through the Peer-observation professional development programme. *South African Journal of Education*, 40(3), 22.
- Drexler-Dreis, J. (2018). *Decolonial love: Salvation in colonial modernity*. Fordham Univ. Press.
- DSI-NRF Centre in Indigenous Knowledge Systems. (2021). Professional Development Workshop – 6<sup>th</sup> May 2021, Department of Science and Innovation. <https://ciks.org.za/>
- du Plessis, M. (2021). Police and Power in a Pandemic: Reflections on the Rise of Police Brutality during COVID-19 and Its Implications on Social Justice in South Africa. *Pretoria Student L. Rev.*, 15, 38.
- Dussel, E. (2019). World-system and "trans"-modernity. In *Unbecoming Modern* (pp. 165-188). Routledge.
- D'Alessandro, C., & Zulu, L. C. (2017). From the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs): Africa in the post-2015 development agenda. A geographical perspective. *African Geographical Review*, 36(1), 1-18.
- Eastwood, V. (2021). Concerns over 'insanity' of Shell South Africa fracking plans, CNN Business, [Concerns over 'insanity' of Shell South Africa fracking plans - CNN](#)
- Education, training and innovation in the National Development Plan 2030. (2013). *South African Journal of Science*, 109(1-2), 1.
- Egron-Polak, E. (2016). Education 2030 – Implications/challenges for higher education, UNESCO-IIEP 9 May 2016, Paris, International Association of Universities (IAU). <http://www.iau-hesd.net/>
- Eizenberg, E., & Jabareen, Y. (2017). Social sustainability: A new conceptual framework. *Sustainability*, 9(1), 68.
- Ekere, O. D. (2022). Mental Decolonisation: towards a Self-Reliant Africa. In *Africa's*

*Radicalisms and Conservatisms* (pp. 327-347). Brill.

- Elder, H., & Kersten, P. (2015). Whakawhiti kōrero, a method for the development of a cultural assessment tool, Te Waka Kuaka, in Māori traumatic brain injury. *Behavioural neurology*, 2015(1-8).
- Eldridge, S., Bond, C., Campbell, M., Hopewell, S., Thabane, L., Lancaster, G., & Coleman, C. (2016). Defining feasibility and pilot studies in preparation for randomised controlled trials: using consensus methods and validation to develop a conceptual framework. *Trials*, 16(2), 1-1.
- Ellen MacArthur Foundation. (2013). *Towards a circular economy*. Cowes.
- Emeagwali, G. (2003). African indigenous knowledge systems (AIK): Implications for the curriculum. *Ghana in Africa and the world: Essays in honour of AduBoahen*, Africa World Press, New Jersey.
- Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*, 5(1), 1-4.
- Fadeeva, Z., Mochizuki, Y., Hopkinson, P., & James, P. (2010). Practical pedagogy for embedding ESD in science, technology, engineering and mathematics curricula. *International Journal of Sustainability in Higher Education*, 11(4), 21-24.
- Fanon, F. (1952). The negro and psychopathology. In C. L. Markmann (Ed.), *Black skin, white masks* (pp. 17-40). France: Éditions du Seuil.
- Fanon, F. (1967). *Black skins White masks*. London: Pluto Press.
- Fataar, A. (2018). Decolonising education in South Africa: Perspectives and debates. *Educational Research for Social Change*, 7(SPE), vi-ix.
- Feeney, A. (2017). Forty years of progress on category-based inductive reasoning. In *The Routledge international handbook of thinking and reasoning*, Routledge.
- Fink, L. D. (2013). *Creating significant learning experiences: An integrated approach to designing college courses*. John Wiley & Sons.
- Fourie, W. (2018). Aligning South Africa's National Development Plan with the 2030 Agenda's Sustainable Development Goals: Guidelines from the policy coherence for development movement. *Sustainable Development*, 26(6), 765-771.
- Fricker, M. (2007). *Epistemic injustice: Power and the ethics of knowing*. Oxford University Press.
- Fundisa for Change Programme. (2021). *Introductory Core Text*. Environmental Learning Research Centre, Rhodes University, Grahamstown.
- Gabriel, M. (2018). *Neo-existentialism*. John Wiley & Sons.

- Ghafouri, R., & Ofoghi, S. (2016). Trustworth and rigour in qualitative research. *International Journal of Advanced Biotechnology of Applied Behavioral Science*, 7(2016), 90-101.
- Gibbs, G. R. (2018). *Analysing qualitative data* (Vol. 6). Sage.
- Gillies, C., Burleigh, D., Snowshoe, A., & Werner, D. (2014). Walking in circles: Self-location in Indigenous youth violence prevention research. *Journal of the Manitoba First Nations Education Resource Centre*, 6(1), 5-25.
- Goosen, L. (2018). Ethical data management and research integrity in the context of e-schools and community engagement. In *Ensuring Research Integrity and the Ethical Management of Data* (pp. 14-45). IGI Global.
- Gorman, J. (2015). What's love got to do with transformative education? In *Journal of Sustainability Education*. 1(1), 2-3. Retrieved from <http://www.jsedimensions.org/>
- Govender, V. (2022). Adaptive reuse of architecture as a response to insurgency and decay in the Durban city centre towards resilient cities in South Africa. *Unpublished PhD thesis*, College of Humanities, University of KwaZulu- Natal.
- Govender, N., Mudaly, R., & James, A. (2013). Indigenous knowledge of custodians of Zulu culture—Implications for multilogical dialogue in the academy. *Alternation*, 20(1), 154-177.
- Govender, N., & Mudzamiri, E. (2022). Incorporating indigenous artefacts in developing an integrated indigenous-pedagogical model in high school physics curriculum: views of elders, teachers and learners. *Cultural Studies of Science Education*, 17(3), 827-850.
- Görg, C., Brand, U., Haberl, H., Hummel, D., Jahn, T., & Liehr, S. (2017). Challenges for social-ecological transformations: Contributions from social and political ecology. *Sustainability*, 9(7), 1045.
- Gray, D. E. (2016). *Doing research in the real world*. Sage.
- Grosfoguel, R. (2012). The dilemmas of ethnic studies in the United States: Between liberal multiculturalism, identity politics, disciplinary colonisation, and decolonial epistemologies. *Human Architecture: Journal of the Sociology of Self-Knowledge*, 10(1), 9.
- Grosfoguel, R. (2013). The structure of knowledge in westernised universities: Epistemic racism/sexism and the four genocides/epistemicides. *Human Architecture: Journal of the sociology of self-knowledge*, 1(1), 73-90.
- Grosfoguel, R., Oso, L., & Christou, A. (2015). 'Racism', intersectionality and migration studies: framing some theoretical reflections. *Identities*, 22(6), 635-652.
- Gunawan, J. (2015). Ensuring trustworthiness in qualitative research. *Belitung Nursing*

*Journal*, 1(1), 10-11.

Habermas, J. (2018). *The postnational constellation: Political essays*. John Wiley & Sons.

Hall, B. L., & Tandon, R. (2017). Decolonisation of knowledge, epistemicide, participatory research and higher education. *Research for all*, 1(1), 6-19.

Heleta, S. (2016). Decolonisation of higher education: Dismantling epistemic violence and Eurocentrism in South Africa. *Transformation in Higher Education*, 1(1), 1-8.

Hewson, M. G. (2013). Traditional Healers' views on their indigenous knowledge and the science curriculum. *African Journal of Research in Mathematics, Science and Technology Education*, 16(3), 317-332.

Higgins, M. (2014). De/colonising pedagogy and pedagogue: Science education through participatory and reflexive videography. *Canadian Journal of Science, Mathematics and Technology Education*, 14(2), 154-171.

Higgs, P. (2012). African philosophy and the decolonisation of education in Africa: Some critical reflections. *Educational Philosophy and Theory*, 44 (2), 37-55.

Higgs, P. (2016). The African renaissance and the transformation of the higher education curriculum in South Africa. *Africa Education Review*, 13(1), 87-101.

Hickel, J., & Kallis, G. (2020). Is green growth possible?. *New political economy*, 25(4), 469-486.

Hlatshwayo, M. N., Adendorff, H., Blackie, M. A., Fataar, A., & Maluleka, P. (Eds.). (2022). *Decolonising Knowledge and Knowers: Struggles for University Transformation in South Africa*. Taylor & Francis.

Hlatshwayo, M. N., & Shawa, L. B. (2020). Towards a critical re-conceptualisation of the purpose of higher education: the role of Ubuntu-Currere in re-imagining teaching and learning in South African higher education. *Higher Education Research & Development*, 39(1), 26-38.

Hlatshwayo, M. N., Shawa, L. B., & Nxumalo, S. A. (2020). Ubuntu currere in the academy: a case study from the South African experience. *Third World Thematics: A TWQ Journal*, 5(1-2), 120-136.

Hodson, D. (2009). *Teaching and learning about science: Language, theories, methods, history, traditions and values*. Brill.

Holmes, B., & McLean, M. (2018). *The curriculum: A comparative perspective*. Routledge.

Hountondji, P. J. (Ed.). (1997). *Endogenous knowledge: Research trails*. Conseil Pour Le Developement De.

Hountondji, P. J. (2009). Knowledge of Africa, Knowledge by Africans: Two perspectives on African studies. *RCCS Annual Review*, 1. Retrieved

from [http://www.ces.uc.pt/publicacoes/annualreview/media/2009%20issue%20n.%201/AR1\\_6.PHountondji\\_RCCS80.pdf](http://www.ces.uc.pt/publicacoes/annualreview/media/2009%20issue%20n.%201/AR1_6.PHountondji_RCCS80.pdf)

- Huckle, J., & Wals, A. E. (2015). The UN Decade of Education for Sustainable Development: business as usual in the end. *Environmental Education Research*, 21(3), 491-505.
- Huebner, D. (1990). *Spirituality and knowing*. In: E. W. Eisner (Ed.) *Learning and teaching the ways of knowing*, (pp. 159-173), Chicago.
- Ikerd, J. E. (2012). *The essentials of economic sustainability*. Bloomfield: Kumarian Press.
- Ismail, R. (2017). *Exploring how Science teachers engage in curriculum innovating in environment and sustainability education* (Doctoral dissertation). University of KwaZulu-Natal. 36-112.
- Jackson-Lowman, H. (2014). *Sankofa: A Black mental health imperative*. In Reginald L. Jones (Ed.) *African American Mental Health*. Hampton, VA: Cobb & Henry Publishers.
- Jansen, J. (2017). Introduction – Part II Decolonising the university curriculum given a dysfunctional school system. *Journal of Educational Studies*, 1(68), 3-13.
- 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*. ISTE Conference. North-West University & Mphebotho Museum.
- Jickling, B., Lotz-Sisitka, H., Olvitt, L., O'Donoghue, R., Schudel, I., McGarry, D., & Niblett, B. (2021). *Environmental Ethics: A Sourcebook for Educators*. African Sun Media.
- Jomo, K. S. (2016). Carpe Diem: Bandung, historical inequalities and development goals. *Inter-Asia Cultural Studies*, 17(1), 27-32.
- Jones, P., Comfort, D., & Hiller, D. (2011). Sustainability in the global shop window, *International Journal of Retail & Distribution Management*, 33(12), 882-892.
- Jones, P., Trier, C. J., & Richards, J. P. (2008). Embedding education for sustainable development in higher education: A case study examining common challenges and opportunities for undergraduate programmes. *International Journal of Educational Research*, 47(6), 341-350.
- Joseph, G. G. (1987). Foundations of Eurocentrism in mathematics. *Race & Class*, 28(3), 13-28.
- Joshua, U., & Bekun, F. V. (2020). The path to achieving environmental sustainability in South Africa: the role of coal consumption, economic expansion, pollutant emission, and total natural resources rent. *Environmental Science and Pollution Research*, 27(9), 9435-9443.
- Joshi, A., Morales, L. G., Klarman, S., Stellato, A., Helton, A., Lovell, S., & Haczek, A. (2021).

- A knowledge organization system for the united nations sustainable development goals. In *The Semantic Web: 18th International Conference, ESWC 2021, Virtual Event, June 6–10, 2021, Proceedings 18* (pp. 548-564). Springer International Publishing.
- Junior, E. H. F., & Kokofele, K. (2019). Review on the drafting process and comparison of millennium development goals and sustainable development goals. *International Journal of Engineering and Techniques*, 5(3), 4-9.
- Kahle, L. R., & Gurel-Atay, E. (Eds.). (2013). *Communicating sustainability for the green economy*, (pp. 86-100), ME Sharpe.
- Kamanzi, B. (2016). Decolonising the curriculum—A student call in context. *Univ. World News*. Retrieved from <http://www.universityworldnews.com/article.php?story=20160527145138375>.
- Kasa, S. (2017). Industrial revolutions and environmental problems, Interdisciplinary Communications. Retrieved from [http://www.cas.uio.no/Publications/Seminar/Confluence\\_Kasa.pdf](http://www.cas.uio.no/Publications/Seminar/Confluence_Kasa.pdf).
- Kaschula, R. H. (2017). Technauriture as a Platform to Create an Inclusive Environment for the Sharing of Research.”. *Searching for Sharing: Heritage and Multimedia in Africa*, 7, 2.
- Kaya, H. O. (2013). Integration of African indigenous knowledge systems into higher education in South Africa: Prospects and challenges. *Alternation*, 20(1), 135-153.
- Keane, M., Khupe, C., & Seehawer, M. (2017). Decolonising methodology: Who benefits from indigenous knowledge research? *Educational Research for social change*, 6(1), 12-24.
- Keet, A. (2014). Epistemic othering and the decolonisation of knowledge. *Africa Insight*, 44(1), 23-37.
- Keval, H. (2019). Navigating the ‘decolonising’ process: avoiding pitfalls and some do’s and don’t’s. *Discover Society*, 65.
- Khupe, C., & Keane, M. (2017). Towards an African education research methodology: Decolonising new knowledge. *Educational Research for Social Change*, 6(1), 25-37.
- Kibirige, I., & Van Rooyen, H. (2007). *Enriching science teaching through the inclusion of indigenous knowledge*. In H. Van Rooyen and J. de Beer (Eds.), *Teaching science in the OBE classroom*. Macmillan.
- Kimmel, M. (2017). *Manhood in America*. Oxford University Press.
- Kincheloe, J. L. (2008). Critical Pedagogy in the. *Critical Pedagogy: Where are We Now? Critical pedagogy primer*, 1(1), 1-9.

- Kiti, P. (2013). Recentring Africa: From Paulin Hountondji to Meinrad Herbga. In Mudaly, R. (2018). Towards decolonising a module in the pre-service science teacher education curriculum: The role of IKS in creating spaces for transforming the curriculum. *Journal of Education*, 74, 47-66. <https://doi.org/https://doi.org/10.17159/2520-9868/i74a04>
- Klarin, T. (2018). The concept of sustainable development: From its beginning to the contemporary issues. *Zagreb International Review of Economics and Business*, 21(1), 67-94.
- Knight, J. (2018). Decolonising and transforming the geography undergraduate curriculum in South Africa. *South African Geographical Journal*, 100(3), 271-290.
- Knowles, M. S. (1975). *Self-directed learning: A guide for learners and teachers*, New York, NY: Association Press.
- Knudsen, B. T., & Andersen, C. (2019). Affective politics and colonial heritage, Rhodes Must Fall at UCT and Oxford. *International Journal of Heritage Studies*, 25(3), 239-258.
- Komatsu, H., Rappleye, J., & Silova, I. (2019). Culture and the Independent Self: Obstacles to environmental sustainability? *Anthropocene*, 26, 11-98.
- Komparic, A. (2015). The Ethics of Introducing GMOs into sub-Saharan Africa: Considerations from the sub-Saharan African Theory of Ubuntu. *Bioethics*, 29(9), 604-612.
- Korstjens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *European Journal of General Practice*, 24(1), 120-124.
- Kriek, J., & Grayson, D. (2009). A holistic professional development model for South African physical science teachers. *South African journal of education*, 29(2), 56-60.
- Kruger, F. (2016). Posthumanism and educational research for sustainable futures. *Journal of Education*, (65), 77-94.
- Kwarteng, A. K. (2016). The Sankofa Bird and Reflection. *Journal of Applied Christian Leadership*, 10(1), 60-69.
- Kwon, O. N., Park, J. H., Park, J. S., & Park, J. (2017). A Community-Based, Practice-Oriented Teacher Professional Development Program: Changes in Teaching Culture in Korea. In *Professional Development of Mathematics Teachers* (pp. 141-157), Springer.
- Kyngäs, H., Kääriäinen, M., & Elo, S. (2020). *The Trustworthiness of Content Analysis. In The Application of Content Analysis in Nursing Science Research*. Springer, Cham.
- Lamont, M. (2018). Addressing recognition gaps: Destigmatization and the reduction of inequality. *American Sociological Review*, 83(3), 419-444.
- Leavy, P. (2017). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*. Guilford Press.

- Lebeloane, L. D. M. (2017). Decolonising the school curriculum for equity and social justice in South Africa. *Koers Bulletin for Christian Scholarship*, 82(3), 1-10.
- Lee, H., Yen, C. F., & Aikenhead, G. S. (2012). Indigenous elementary students' science instruction in Taiwan: Indigenous knowledge and western science. *Research in Science Education*, 42, 1183-1199.
- Le Grange, L. (2014). Currere's active force and the Africanisation of the university curriculum. *South African Journal of Higher Education*, 28(4), 1283-1294.
- Le Grange, L. (2016). Decolonising the university curriculum. *South African Journal of Higher Education*, 30(2), 1–12.
- Le Grange, L. (2018). Decolonising, Africanising, indigenising, and internationalising curriculum studies: Opportunities to (re) imagine the field. *Journal of Education (University of KwaZulu- Natal)*, (74), 4-18.
- Le Grange, L. (2019). Currere's active force and the concept of Ubuntu. In *Internationalizing Curriculum Studies*. Palgrave Macmillan, Cham.
- Le Grange, L. (2021). (Individual) responsibility in decolonising the university curriculum. *South African Journal of Higher Education*, 35(1), 4-20.
- Leicht, A., Heiss, J., & Byun, W. J. (2018). *Issues and trends in education for sustainable development* (Vol. 5). UNESCO publishing.
- Lemaire, E. (2020). Engaging preservice students in decolonising education through the blanket exercise. *Language and Intercultural Communication*, 20(4), 300-311.
- Le Roux, J. (2021). A whale of a tale: The huge momentum shift in the story of two environmental campaigns against Shell — a decade apart. Daily Maverick, [The huge momentum shift in the story of two environment... \(dailymaverick.co.za\)](https://www.dailymaverick.co.za/article/2021-05-11-a-whale-of-a-tale-the-huge-momentum-shift-in-the-story-of-two-environmental-campaigns-against-shell-a-decade-apart/)
- Li, H. C., & Tsai, T. L. (2022). Education for sustainable development in mathematics education: what could it look like? *International Journal of Mathematical Education in Science and Technology*, 53(9), 2532-2542.
- Lingán, J., Cornforth, J., & Pollard, R. (2012). Sustainable development goals: building the foundations for an inclusive process. In *Stakeholder Forum for a Sustainable Future* [https://stakeholderforum.org/fileadmin/files/BOND\\_SDGs\\_Paper\\_%20May\\_2012.pdf](https://stakeholderforum.org/fileadmin/files/BOND_SDGs_Paper_%20May_2012.pdf)
- Lotz-Sisitka, H. (2013). Think Piece: Conceptions of Quality and 'Learning as Connection'-Teaching for Relevance. *Southern African Journal of Environmental Education*, (29), 25-38.
- Lotz-Sisitka, H. (2017). Chapter 2 Decolonisation as future frame for environmental and sustainability education: embracing the commons with absence and emergence. In *Envisioning futures for environmental and sustainability education* (p. 21).

Wageningen Academic Publishers.

- Lotz-Sisitka, H. (2018). *Tensions and contradictions in the SDGs in Africa*. Port Elizabeth, South Africa: Future Earth,  
<https://www.facebook.com/futureearth.org/videos/1779126972110844/>
- Lotz-Sisitka, H., & Lupele, J. (2017). ESD, learning and quality education in Africa: Learning today for tomorrow. In *Schooling for sustainable development in Africa*. Springer, Cham.
- Lotz-Sisitka, H., Mandikonza, C., Misser, S., & Thomas, K. (2021). Making Sense of Climate Change in a National Curriculum (pp. 92-96), in *Teaching and Learning for Change*. African Minds. <https://www.africanminds.co.za/teaching-learning-change/>
- Lotz-Sisitka, H. B., Tshiningayamwe, S., & Urenje, S. (2017). Sustainability Starts with Teachers. *An ESD professional development programme for secondary teacher educators. Introduction and overview*. *South African Journal of Environmental education* 2(1) 12-27.
- Macrina, F. L. (2014). *Scientific integrity: Text and cases in responsible conduct of research*. John Wiley & Sons.
- Madlingozi, T. (2017). Social justice in a time of neo-apartheid constitutionalism: Critiquing the anti-black economy of recognition, incorporation and distribution. *Stellenbosch Law Review*, 28(1), 123-147.
- Magni, G. (2017). Indigenous knowledge and implications for the sustainable development agenda. *European Journal of Education*, 52(4), 437-447.
- Magrini, J. M. (2016). A conceptual-phenomenological approach to exploring education: Re-conceiving standardized curriculum in terms of a poetic, transcendent, and complicated conversation. *Linguistic and Philosophical Investigations*, (15), 167-202.
- Majid, M. A. A., Othman, M., Mohamad, S. F., Lim, S. A. H., & Yusof, A. (2017). Piloting for interviews in qualitative research: Operationalization and lessons learnt. *International Journal of Academic Research in Business and Social Sciences*, 7(4),1073-1080.
- Maldonado-Torres, N. (2007). On the Coloniality of Being: Contributions to the Development of a Concept. *Culture Studies*, 21(2-3), 240-270.
- Maldonado-Torres, N. (2011). Thinking through the decolonial turn: post-continental interventions in theory, philosophy, and critique—An introduction. *Transmodernity: Journal of Peripheral Cultural Production of the Luso-Hispanic World*, 1(2) 11-15.
- Maldonado-Torres, N. (2014). AAR centennial roundtable: Religion, conquest, and race in the foundations of the modern/colonial world. *Journal of the American Academy of Religion*, 82(3), 636-665.

- Maringe, F., & Ojo, E. (2017). Sustainable transformation in a rapidly globalizing and decolonising world: African higher education on the brink. In *Sustainable transformation in African higher education* (pp. 25-39). Brill.
- Marshall, J., & Reason, R. (2007). Quality in research as “taking an attitude of inquiry.” *Management Research News*, 30(5), 368–380.
- Martin, F., & Piribhai-Illich, F. (2016). Towards decolonising teacher education: Criticality, relationality and intercultural understanding. *Journal of Intercultural Studies*, 37(4), 355-372.
- Martin, S. N., Suryadi, D., & Juandi, D. (2019). Students’ difficulties in solving the mathematics word problems with the context of Education for Sustainable Development (ESD). *Journal of Physics*, 1157(4), 42-43.
- Matiwane, B. (2017). *The decommodification thesis*. The decolonisation of South African schooling: “looking back, looking forward”. National education collaboration trust. Unisa: DOE.
- Mbembe, A. (2015). Decolonising knowledge and the question of the archive, Public Lecture. *Wits Institute for Social and Economic Research. University of Witwatersrand. Johannesburg.* <http://wiser.wits.ac.za/system/files/Achille%20Mbembe>.
- McDonald, C. V. (2017). Exploring nature of science and argumentation in science education. *Science education: A global perspective*, 7-43.
- McGill University. (2021). Indigenous Knowledge Holder Series. Indigenous Studies Program. Accessed at <https://www.mcgill.ca/indigenous-studies/events/knowledge-holder>
- Mertler, C. A., & Charles, C. M. (2010). Introduction to Educational Research (6<sup>th</sup> ed). Boston: Pearson Education.
- Metz, T. (2009). Higher education, knowledge for its own sake, and an African moral theory. *Studies in Philosophy and Education*, 28(6), 517.
- Mignolo, W. D. (2011). Geopolitics of sensing and knowing: on (de) coloniality, border thinking and epistemic disobedience. *Postcolonial studies*, 14(3), 273-283.
- Mignolo, W. D., & Walsh, C. E. (2018). *On decoloniality: Concepts, analytics, praxis*. Duke University Press.
- Modiri, J. (2016). In the fall: Decolonisation and the rejuvenation of the academic project in South Africa. *The Daily Maverick*, Retrieved from <http://agi.ac.za/news/fall-decolonisation-and-rejuvenation-academic-project-south-africa>
- Mohamed, N. (2018). *Sustainability transitions in South Africa*. Routledge.
- Molefe, T. O. (2016). Oppression must fall: South Africa’s Revolution in theory. *World Policy*

*Journal*, 33(1), 32.

- Moloi, T. (2020). Decolonising the Teaching of Mathematics in Rural Learning Ecologies by Using Indigenous Games. *Rural Ecologies of Teaching and Learning*, 27(2), 125-150.
- Motala, E. (2015). Public scholarship, democracy and scholarly engagement. *Educational Research for Social Change*, 4(2), 22–34.
- Moyo, D. (2011). *Science educators' ideas of the "science" in IKS and their willingness to include IKS in the school science curriculum* (Doctoral dissertation).
- Moyo, S., & Matondi, P. B. (2008). Interrogating sustainable development and resource control in Zimbabwe. *Land and sustainable development in Africa*, 55-82.
- Mudaly, R. (2018a). Towards decolonising a module in the pre-service science teacher education curriculum: The role of indigenous knowledge systems in creating spaces for transforming the curriculum. *Journal of Education*, 74 (2018), 47-66.
- Mudaly, V. (2018b). Decolonising the mind: Mathematics teachers explore possibilities for indigenising the school curriculum. *Journal of Education (University of KwaZulu-Natal)*, (74), 67-84.
- Mudaly, R., & Sanjigadu, S. (2022). Epistemic Journeying across Abyssal Lines of Thinking: Towards Reclaiming Southern Voices. *Education as Change*, 26(1), 1-29.
- Mudaly, R., & Ismail, R. (2013). Teacher learning through tapping into indigenous knowledge systems in the science classroom. *Alternation*, 20(1), 178-202.
- Nakashima, D. J., McLean, K., Thulstrup, H. D., Ramos Castillo, A., & Rubis, J. T. (2012). *Weathering uncertainty: traditional knowledge for climate change assessment and adaptation*. Paris: UNESCO, and Darwin: UNU.
- Nasibulina, A. (2015). Education for sustainable development and environmental ethics. *Procedia-Social and Behavioral Sciences*, 214, 1077-1082.
- National Planning Commission. (2015). National Development Plan 2030: Our Future – Make it Work National Planning Commission, The Presidency, Republic of South Africa.
- Natkin, L. W., & Kolbe, T. (2016). Enhancing Sustainability Curricula through Faculty Learning Communities. *International Journal of Sustainability in Higher Education*, 17(4), 540-558.
- Ndlovu-Gatsheni, S. J. (2015). Decoloniality as the future of Africa. *History Compass*, 13(10), 485-496.
- Ndlovu-Gatsheni, S. J. (2017). The emergence and trajectories of struggles for an 'African university': The case of unfinished business of African epistemic decolonisation. *Kronos*, 43(1), 51-77.

- Ndlovu-Gatsheni, S. J. (2018). *Epistemic freedom in africa: Deprovincialization and decolonisation (Rethinking development)*. Abingdon, Oxon: Routledge.
- Ndlovu-Gatsheni, S. J., & Mporu, B. (2019). *Rethinking and Unthinking Development: Perspectives on Inequality and Poverty in South Africa and Zimbabwe*, Berghahn Books.
- Ndonga, D., Laryea, E., & Chaponda, M. (2020). Assessing the potential impact of the African continental free trade area on least developed countries: A case study of Malawi. *Journal of Southern African Studies*, 46(4), 773-792.
- Ng'asike, J. T. (2019). Indigenous knowledge practices for sustainable lifelong education in pastoralist communities of Kenya. *International Review of Education*, 65(1), 19-46.
- Ningsih, S. Y., & Juandi, D. (2019, February). Achievement of ESD (Educational for Sustainable Development) through mathematics learning. In *Journal of Physics: Conference Series* (Vol. 1157, No. 4, p. 042056). IOP Publishing.
- Nkrumah, K. (1967). Neo-Colonialism: The Last Stage of Imperialism. *Science and Society*, 31(1).
- Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence-based nursing*, 18(2), 34-35.
- Nolet, V. (2013). Teacher education and ESD in the United States: The vision, challenges, and implementation. In *Schooling for sustainable development in Canada and the United States* (pp. 53-67). Springer.
- Nordling, L. (2018). How decolonisation could reshape South African science. *Nature*, 554(7691) 12.
- Noxolo, P. (2017). Decolonial theory in a time of the re-colonisation of UK research. *Transactions of the Institute of British Geographers*, 42(3), 342-344.
- Oelofsen, R. (2015). Decolonisation of the African mind and intellectual landscape. *Phronimon*, 16(2), 130- 146.
- Ogunniyi, M. B. (2011). The context of training teachers to implement a socially relevant science education in Africa. *African Journal of Research in Mathematics, Science and Technology Education*, 15(3), 98–121.
- Ogunniyi, M. M. (2023). Culturally Responsive Science Education for Indigenous and Ethnic Minority Students. In *Handbook of Research on Science Education* (pp. 389-410). Routledge.
- Ololade, O. O. (2018). Understanding the nexus between energy and water: A basis for human survival in South Africa. *Development Southern Africa*, 35(2), 194-209.
- Oluwatayo, I. B., & Ojo, A. O. (2018). Walking through a tightrope: the challenge of economic

- growth and poverty in Africa. *The Journal of Developing Areas*, 52(1), 59-69.
- Omer, A. (2020). Decolonising religion and the practice of peace: Two case studies from the postcolonial world. *Critical research on religion*, 8(3), 273-296.
- Opoku, M. J., & James, A. (2021). Pedagogical Model for Decolonising, Indigenising and Transforming Science Education Curricula: A Case of South Africa. *Journal of Baltic Science Education*, 20(1), 93.
- 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.
- Oxfam. (2013). Annual report 2013. Retrieved from <https://www.oxfamamerica.org/explore/research-publications/annual-report-2013/>.
- O'Donoghue, R. (2013). Framing Active Teaching and Learning in CAPS. *Knowledge Teaching and Assessment for a whole School Approach to environmental and sustainability Education. Pretoria: Fundisa for Change.*
- Padayachee, K., Matimolane, M., & Ganas, R. (2018). Addressing curriculum decolonisation and education for sustainable development through epistemically diverse curricula: HELTASA conference papers. *South African Journal of Higher Education*, 32(6), 288-304.
- Paphitis, S. A., & Kelland, L. (2016). The university as a site for transformation: developing civic-minded graduates at South African institutions through an epistemic shift in institutional culture. *Education as Change*, 20(2), 184-203.
- Paraskeva, J. M., & Steinberg, S. R. (Eds.). (2016). *Curriculum: Decanonizing the field*. New York: Peter Lang.
- Parker, R., & Ferraz, D. (2021). Politics and pandemics. *Global Public Health*, 16(8-9), 1131-1140.
- Patton, K., & Parker, M. (2017). Teacher education communities of practice: More than a culture of collaboration. *Teaching and Teacher Education*. 67, 351-360.
- Payne, M., & Barbera, J. R. (Eds.). (2013). *A dictionary of cultural and critical theory*. John Wiley & Sons.
- Peel, K. L. (2020). A beginner's guide to applied educational research using thematic analysis. *Practical Assessment, Research, and Evaluation*, 25(1), 2.
- Pete, S. (2015). 100 ways to Indigenize and decolonise academic programs and courses.

University of Regina. Retrieved from

<https://www.uregina.ca/president/assets/docs/presidentdocs/indigenization/indigenize-decolonise-university-courses.pdf>

- Pete, S., Schneider, B., & O'Reilly, K. (2013). Decolonising our practice: Indigenizing our teaching. *First Nations Perspectives*, 5(1), 99-115.
- Petersen, N., & White, L. (2018). *The rhizomic development from STEM to STEAM education: Using puppetry in Life Sciences*. In Proceedings of the 9th Annual ISTE Conference.
- Pham, L. T. M. (2018). *Qualitative Approach to Research, A review of Advantages and Disadvantages of three paradigms: Positivism, Interpretivism and Critical Inquiry*. University of Adelaide. Australia.
- Pinar, W. F. (1978). The reconceptualisation of curriculum studies. *Journal of Curriculum Studies*, 10(3). 205–214.
- Pinar, W. F. (2012). *What is curriculum theory?* (2 ed.). Routledge.
- Pipere, A., & Mičule, I. (2014). Mathematical Identity for a Sustainable Future: An Interpretative Phenomenological Analysis. *Journal of Teacher Education for Sustainability*, 16(1), 5-31.
- Pitcher, S., & Jones, N. (2018). Decolonising & Africanising: Discussing Current Challenges of Curriculum Development in a South African University Journalism Programme. In *Conference Proceedings. The Future of Education* (p. 369). libreriauniversitaria. it Edizioni.
- Pollard, A., Black-Hawkins, K., Cliff-Hodges, G., Dudley, P., & James, M. (2014). *Reflective Teaching in Schools: Evidence-Informed Professional Practice*. Bloomsbury Publishing.
- Postiglione, G. A. (2017). *The decolonisation of Hong Kong education. In Education and society in Hong Kong: Toward one country and two systems*. Routledge.
- Passada, M. N. M. (2019). Discourses analysis by a decolonial perspective. In *Advances in Discourse Analysis*. IntechOpen.
- Pratt, Y. P., Louie, D. W., Hanson, A. J., & Ottmann, J. (2018). *Indigenous education and decolonisation*. In Oxford Research Encyclopedia of Education. Retrieved from <https://oxfordre.com/education/view/10.1093/acrefore/9780190264093.001.0001/acrefore-9780190264093-e-240>
- Purohit, H. S., & Taylor, L. S. (2015). Phase separation kinetics in amorphous solid dispersions upon exposure to water. *Molecular pharmaceuticals*, 12(5), 1623-1635.
- Quijano, A. (2000). Coloniality of power and Eurocentrism in Latin America. *International sociology*, 15(2), 215-232.

- Raju, C. K. (2012). Decolonising math and science education. *Decolonising The University: The Emerging Quest for Non-Eurocentric Paradigms*. Pulau Pinang: Penerbit Universiti Sains Malaysia.
- Raju, C. K. (2017). Black thoughts matter: decolonised math, academic censorship, and the “Pythagorean” proposition. *Journal of Black Studies*, 48(3), 256-278.
- Ralph, E. G. (2014). The effectiveness of microteaching: Five years’ findings. *International Journal of Humanities Social Sciences and Education*, 1(7), 17-28.
- Rapplee, J., & Komatsu, H. (2016). Living on borrowed time: Rethinking temporality, self, nihilism, and schooling. *Comparative education*, 52(2), 177-201.
- Reade, C., Reckmeyer, W. J., Cabot, M., Jaehne, D., & Novak, M. (2013). Educating global citizens for the 21st century: The SJSU Salzburg program. *Journal of Corporate Citizenship*, (49), 100-116.
- Reddy, B. S. (2015). Access to modern energy services: An economic and policy framework. *Renewable and Sustainable Energy Reviews*, 47, 198-212.
- Reddy, C. (2017). Environmental education in teacher education: A viewpoint exploring options in South Africa. *Southern African Journal of Environmental Education*, 33, 117-126.
- Remesh, A. (2013). Microteaching, an efficient technique for learning effective teaching. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, 18(2), 158-221.
- Renert, M. (2011). Mathematics for life: Sustainable mathematics education. *For the Learning of Mathematics*, 31(1), 20-26.
- Resnik, D. B. (2015). What is Ethics in Research and why it is Important? *National Institute for Environmental Health Sciences*. Retrieved from: <http://www.niehs.nih.gov/research/resources/bioethics/whatis>
- Rubin, A., & Babbie, E. (2017). *Research Methods for Social. Work*. Boston, MA: Cengage Learning.
- Sarmiento, J. M. H., Osorio, V. L. D., Sánchez, L. M. M., Serna, L. R., Ospina, D. C. G., Montoya, .....& Gil, J. J.G. (2013). Tuberculosis in indigenous communities of Antioquia, Colombia: Epidemiology and beliefs. *Journal of immigrant and minority health*, 15(1), 10-16.
- Sathorar, H., & Geduld, D. (2018). Towards decolonising teacher education: Reimagining the relationship between theory and praxis. *South African Journal of Education*, 38(4).
- Sauce, B., & Matzel, L. D. (2017). Inductive Reasoning. *Encyclopaedia of animal cognition and*

behaviour. Retrieved from [https://www.researchgate.net/profile/Bruno-Sauce/publication/318155680\\_Inductive\\_Reasoning/links/5a8c6ea8a6fdcc786eafd387/Inductive-Reasoning.pdf](https://www.researchgate.net/profile/Bruno-Sauce/publication/318155680_Inductive_Reasoning/links/5a8c6ea8a6fdcc786eafd387/Inductive-Reasoning.pdf)

- Scheyvens, R., Banks, G., & Hughes, E. (2016). The private sector and the SDGs: The need to move beyond 'business as usual'. *Sustainable Development*, 24(6), 371-382.
- Schutt, R. K. (2018). *Investigating the social world: The process and practice of research*. Sage publications.
- Scott, J. C. (2017). *Against the grain*. Yale University Press.
- Seabi, J., Seedat, J., Khoza-Shangase, K., & Sullivan, L. (2014). Experiences of university students regarding transformation in South Africa. *International Journal of Educational Management*, 28(1), 66–81.
- Shava, S., Makokotlela, M. V., & Hebe, H. (2020). Role of SDGs in Reconceptualising the Education for Sustainable Development Curriculum in Higher Education in South Africa. *Scaling up SDGs Implementation*. Development and private sectors. Springer, Cham.
- Shay, S. (2015). Curriculum reform in higher education: a contested space. *Teaching in Higher Education*, 20(4), 431-441.
- Sheng, E. L., & Basaruddin, F. (2014). Ways of improving students' performances in assessments from instructors and students' perspectives. *International Journal of Asian Social Science*, 4(2), 301-306.
- Shiva, V. (2016). *Soil, not oil: climate change, peak oil and food insecurity*. Bloomsbury Publishing.
- Shizha, E. (2017). Indigenous Knowledges and Knowledge Codification in the Knowledge Economy. In *Handbook of Research on Theoretical Perspectives on Indigenous Knowledge Systems in Developing Countries* (pp. 267- 288). IGI Global.
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-22.
- Shumba, O., Mandikonza, C., & Lotz-Sisitka, H. (2020). Advancing Assessment Thinking in Education for Sustainable Development with a Focus on Significant Learning Processes. In *Teaching and Learning for Change*, (pp. 201). African Minds.
- Shumba, O., & Kampamba, R. (2013). Mainstreaming ESD into science teacher education courses: A case for ESD pedagogical content knowledge and learning as connection. *Southern African Journal of Environmental Education*, 29, 151-166.
- Sim, J., & Waterfield, J. (2019). Focus group methodology: some ethical challenges. *Quality &*

*Quantity*, 53(6), 3003-3022.

- Sinakou, E., Boeve-de Pauw, J., Goossens, M., & Van Petegem, P. (2018). Academics in the field of Education for Sustainable Development: Their conceptions of sustainable development. *Journal of cleaner production*, 184(1), 321-332.
- Singh, S. (2020). From global north-south divide to sustainability: shifting policy frameworks for international development and education. *International and Multidisciplinary Journal of Social Sciences*, 9(1), 76-102.
- Singh, S. K. (2011). The role of staff development in the professional development of teachers: Implications for in-service training. *South African Journal of Higher Education*, 25(8), 1626-1638.
- Sium, A., Desai, C., & Ritskes, E. (2012). Towards the 'tangible unknown': Decolonisation and the Indigenous future. *Decolonisation: indigeneity, education & society*, 1(1).
- Smith, L. T. (1999). *Decolonising Methodologies: Research and Indigenous Peoples*. London, UK: Zed Books Ltd.
- Song, B. K. (2021). E-portfolio implementation: Examining learners' perception of usefulness, self-directed learning process and value of learning. *Australasian Journal of Educational Technology*, 37(1), 68-81.
- Soyinka, W. (2021). *Chronicles from the Land of the Happiest People on Earth*. Bloomsbury Publishing.
- Spivak, G. C. (1988). *Can the subaltern speak?* in Nelson C and Grossberg L *Marxism and the interpretation of culture* (pp. 271-313). University of Illinois Press.
- Steber, C. (2017). *In-Depth Interviews: Data Collection Advantages and Disadvantages*. Market Research Blog. Accessed at <https://www.cfrinc.net/cfrblog/in-depth-Interviewing>.
- Stevens, M. (2017). *What Is Environmental Sustainability and Why Is It Important*. Sustainable Friends. <http://www.sustainablefriends.com/what-is-environmental-sustainability-why-is-it-important/>
- Stevenson, R. B., Nicholls, J., & Whitehouse, H. (2017). What is climate change education? *Curriculum Perspectives*, 37(1), 67-71.
- Strydom, H. (2011). Ethical aspects of research in the social sciences and human service professions. *Research at grass roots for the social sciences and human service professions*, 4, 113-129.
- Suaalii-Sauni, T., & Fulu-Aiolupotea, S. M. (2014). Decolonising Pacific research, building Pacific research communities and developing Pacific research tools: The case of the talanoa and the faafaletui in Samoa. *Asia Pacific Viewpoint*, 55(3), 331-344.
- Subreenduth, S. (2013). Insidious Colonialism in Post-Apartheid Education: Interplay of Black

- Teacher Narratives, Educational Policy and Textbook Analysis. *Qualitative Research in Education*, 2(3), 213-241.
- Takayama, K. (2016). Deploying the post-colonial predicaments of researching on/with 'Asia' in education: A standpoint from a rich peripheral country. *Discourse: Studies in the Cultural Politics of Education*, 37(1), 70-88.
- Takayama, K. (2015). Provincialising the world culture theory debate: Critical insights from a margin. *Globalisation, Societies and Education*, 13(1), 34-57.
- Takyi-Amoako, E. J., & Assié-Lumumba, N. T. (2018). Conclusion: Towards an Ubuntu-Inspired Continental Partnership on Education for Sustainable Development in Africa—African Union Commission Agenda 2063 Education Strategy. In *Re-Visioning Education in Africa*. Palgrave Macmillan, Cham.
- Tang, Q. (2015). *Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4*. Retrieved from: [http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-actionimplementation-of-sdg4-2016-en\\_2.pdf](http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-actionimplementation-of-sdg4-2016-en_2.pdf)
- Taylor, C. (1994). Multiculturalism. In *Multiculturalism*. Princeton University Press.
- Tedesco, J. C., Opertti, R., & Amadio, M. (2014). The curriculum debate: Why it is important today. *Prospects*, 44(4), 527-546.
- Thambinathan, V., & Kinsella, E. A. (2021). Decolonising Methodologies in Qualitative Research: Creating Spaces for Transformative Praxis. *International Journal of Qualitative Methods*, 20, 1-9.
- Thangavel, P., & Sridevi, G. (2016). *Environmental sustainability*. Springer.
- Tikly, L. (2017). The Future of Education for All as a Global Regime of Educational Governance. *Comparative Education Review*, 61(1), 22-57.
- Tikly, L. (2019). Education for sustainable development in Africa: a critique of regional agendas. *Asia Pacific Education Review*, 20(2), 223-237.
- Tooley, M., & Connally, K. (2016). *No panacea: Diagnosing what ails teacher professional development before reaching for remedies*. New America.
- Towle, A., & Cottrell, D. (1996). Self-directed learning. *Archives of disease in childhood*, 74(4), 357-359.
- Trigueros, R., Juan, M., & Sandoval, F. (2017). *Qualitative and quantitative research instruments*. Universidad de Salvador, Retrieved from [https://www.researchgate.net/publication/323014697\\_QUALITATIVE\\_AND\\_QUANTITATIVE\\_RESEARCH\\_INSTRUMENTS\\_Research\\_tools](https://www.researchgate.net/publication/323014697_QUALITATIVE_AND_QUANTITATIVE_RESEARCH_INSTRUMENTS_Research_tools)

- Tuck, E., & Yang, K. W. (2012). Decolonisation is not a metaphor. *Decolonisation: Indigeneity, Education & Society*, 1(1), 1-6.
- Tulloch, L. (2019). Embedding Education for Sustainability (EfS) into Teacher Education in the South Pacific, Challenges and Opportunities. In *Encyclopedia of Teacher Education*, Springer.
- Uleanya, C., Rugbeer, Y., & Olaniran, S. O. (2019). Decolonisation of education: exploring a new praxis for sustainable development. *African Identities*, 17(2), 94-107.
- UNESCO. (2014). *Roadmap for implementing the global action programme on education for sustainable development*. Paris: UNESCO. Retrieved from <http://unesdoc.unesco.org>
- UNESCO. (2015). Rethinking education for the common good. Retrieved from <http://unesdoc.unesco.org/images/0023/002325/232555e.pdf>
- UNESCO. (2016). Education 2030: Incheon declaration and framework for action for the implementation of sustainable development goal 4. The Qingdao declaration. Paris: UNESCO. <http://www.unesco.org/new/en/education/resources/in-focus-articles/qingdao-declaration>
- UNESCO. (2017). *Education for sustainable development goals*, <http://unesdoc.unesco.org/images/0024/>
- UNESCO. (2019). Records of the General Conference (Volume 1) 40<sup>th</sup> session Paris, 12–27 November. Resolutions Corrigendum. Accessed at <https://unesdoc.unesco.org/>
- UNESCO. (2020). Education for Sustainable Development Roadmap. ESD for 2030. <http://www.unesco.org/open-access/terms-use-ccbysa-en>
- United Nations. (2015). *Transforming Our World: the 2030 Agenda for Sustainable Development*. Resolution adopted by the General Assembly on 25 September 2015, A/RES/70/1. UN General Assembly: New York.
- United Nations Economic Commission for Africa. (2012). *Progress towards sustainable development report in Africa*, UNECA, Addis Ababa.
- United Nations Statistical Commission. (2018). *SDG Indicators—Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. United Nations.
- van Jaarsveldt, L. C., de Vries, M. S., & Kroukamp, H. J. (2019). South African students call to decolonise science: Implications for international standards, curriculum development and Public Administration education. *Teaching Public Administration*, 37(1), 12-30.

- Voluntary National Review. (2019). South Africa's implementation of the 2030 agenda for sustainable development. NDP 2030. Accessed at [https://sustainabledevelopment.un.org/content/documents/23402RSA\\_Voluntary\\_National\\_Review\\_report\\_July\\_2019](https://sustainabledevelopment.un.org/content/documents/23402RSA_Voluntary_National_Review_report_July_2019)
- Von Bormann, T., & Gulati, M. (2016). Food, water, and energy: Lessons from the South African experience. *Environment: Science and Policy for Sustainable Development*, 58(4), 4-17.
- Vygotsky, L. (1978). *Mind in society. The development of higher psychological processes.* Cambridge, MA: Harvard University Press.
- Wallin, J. (2010). *A Deleuzian approach to curriculum: Essays on a pedagogical life.* Springer.
- Walter, M. (2005). Using the 'power of the data' within Indigenous research practice. *Australian Aboriginal Studies*, (2), 27-34.
- Wang, J., Yang, M., & Maresova, P. (2020). Sustainable development at higher education in China: A comparative study of students' perception in public and private universities. *Sustainability*, 12(6), 2158.
- Wa Thiong'o, N. (1986). Ngũgĩ. "The Language of African Literature." *Decolonising the Mind: The Politics of Language in African Literature.* Currey.
- Webb, D. (2014). Placemaking and social equity: Expanding the framework of creative placemaking. *Artivate*, 3(1), 35-48.
- Weber, H. (2017). Politics of 'leaving no one behind': contesting the 2030 Sustainable Development Goals agenda. *Globalizations*, 14(3), 399-414.
- Wilmot, D., & Dube, C. (2015). School geography in South Africa after two decades of democracy: teachers' experiences of curriculum change. *Geography*, 100(2), 94-101.
- Wilson, K. (2017). Re-centring 'race' in development: Population policies and global capital accumulation in the era of the SDGs. *Globalizations*, 14(3), 432-449.
- World Bank. (2022). A World Bank report on Inequality in Southern Africa: An Assessment of the Southern African Customs Union. Accessed at <https://documents.worldbank.org>
- World Bank. (2014). Unemployment total (% of total labor force) (modelled ILO estimate) <http://data.worldbank.org/indicator/SL.UEM.TOTL.ZS>.
- Wright, S., Lloyd, K., Suchet-Pearson, S., Burarrwanga, L., Tofa, M., & Country, B. (2012). Telling stories in, through and with Country: engaging with Indigenous and more-than-human methodologies at Bawaka, NE Australia. *Journal of cultural geography*, 29(1), 39-60.

- Yin, R. K. (2018). *Case study research and applications-design and methods*, SAGE Publication.
- 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). *Building bridges across disciplines for transformative education and a sustainable future*, 29, 249-256.
- 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.
- Zinyeka, G. (2016). The epistemological basis of indigenous knowledge systems in science education. University of Pretoria. URI: <http://hdl.handle.net/2263/5297>

## Appendices

### Appendix A1: Observation schedule

Lecture/Student Presentation Observation Form

Group no. \_\_\_\_\_

Lecture / Student Observation number: \_\_\_\_\_

Sign \_\_\_\_\_

The topic of Lecture/Presentation: \_\_\_\_\_

Module/Subject: \_\_\_\_\_

Date and Time \_\_\_\_\_

**Use criteria that apply to the format of the lesson observed.**

Review Section	Description/Comments	
<b>Subject matter content</b> (Topic/Focus area being taught)		
<b>Evidence of Decolonisation with the use of indigenous knowledge in the teaching phase of the lesson</b> ( subject matter; evidence in preparation; Examples and references used in the explanation of the content)		
<b>Rapport of students during lecture/presentation</b> ( interest of students; provides feedback, student interactions; enthusiasm; attitudes;)		
<b>Evidence of focus on the use of leveraging indigenous knowledge</b> (Relevance to South African learners' contexts? Reflects de-colonial, indigenous ideologies?)		
<b>Evidence of focus on addressing the Sustainable Development Goals.</b> (Names of the SDGs presented; clear integration within the Science or		

Review Section	Description/Comments	
<p>Mathematics topic shown; detail on how the SDGs are explicitly addressed within the curriculum; details shown are clear and easily understood by learners).</p>		
<p><b>Evidence of leveraging indigenous knowledge to address the Sustainable Development Goals.</b> (Direct link between the use of IK and addressing the SDGs shown, examples and explanations are easily understood and could be seen as relevant to learners' contexts)</p>		
<p><b>General Observations/Notes/ Points of interest.</b> (Focus on aspects of leveraging indigenous knowledge to address the Sustainable Development Goals)</p>		

## Appendix A2: Observation extracts and discussions from teacher group presentations

### (i) Micro-teaching Observations: Physical Sciences unit of work Grade 10:

#### Hydrosphere

Group presentations by all teacher groups were conducted. The observation of the group presentation by Teacher Group Eight revealed a real commitment to actioning research and collaboration within their unit of work. Learner-centredness was highlighted throughout. Section 6 of the OS looked at “Evidence of focus on the use of leveraging indigenous knowledge”. Group Eight drew on the IsiZulu culture which the majority of the teachers in this study with which their learners identify. The extracts below show my notes on the observation schedule which I recorded during this presentation.

contexts? Reflects de-colonial, indigenous ideologies?)	Drew on “Rain Catchment Tanks”, “Protecting natural springs” and “Installing sand dams”.
	Research showed that Zulu people historically believed that sand/soil cleaned and purified water and they often used soil to clean water.
	Research showed that Zulu people experienced less Water-borne diseases.

#### *Extract from Group Eight’s Micro-teaching presentation*

The focus on localized water purification methods and the research evidence presented by Group Eight showed a real commitment to integrating IK within their selected unit of work. The group actively involved the voices of IK holders in their presentations. Indigenous ideas and views were included in their presentation (see extract below).

7. <b>Voice of an IK holder.</b> Whether knowledge/ views contributed by IK holder was included in presentation.	Within the teaching, elders and IK holders were to offer their anecdotes on how they historically saved water. In their presentation, the group stated that a local Zulu IK holder will be brought into their classrooms to explain local purification and water conservation methods.
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#### *Extract on how views of IK holders were included in the presentation*

The group included the following indigenous content in their lesson plan as a part of the PoE to address SDG 6: Clean water and sanitation. The following indigenous content was included to address this SDG.

Lesson Objective 1: To determine which water purification method would remove the most bacteria from water using indigenous methods such as:

- a. Boiling
- b. Chlorination (putting JIK in water),
- c. Filtration
- d. Sedimentation

Lesson Objective 2: To explore which of the following indigenous water purification methods would decrease the level of bacteria the most:

- a. The Western method of using chemicals to clean polluted water.
- b. The African method of adding Moringa Oleferia seeds to clean polluted water.

The content is focused on obtaining clean water (DA8).

SDG 17 (Partnerships for change) was presented during Group Eight's presentation where they stated that they plan to teach the topic by bringing in an IK holder into the classroom to co-teach with them, as observed above. Engaging the IK holder as a teacher revealed the multiple ways of interpreting reality, which Kincheloe (2008) referred to as multilogicality. This form of collaborative pedagogy where qualified teachers planned to teach with community members (like IK holders) to include IK into the curriculum addresses SDG 17. Group Eight was committed to engaging in "Action" to leverage indigenous methods and technologies for water purification and addressed SDGs 3, 6, and 17 specifically while planning to teach the Hydrosphere from the school Physical Sciences curriculum.

## **(ii) Micro-teaching Observations: Life Sciences unit of work Grade 11:**

### **Cellular respiration**

The group members began their research processes by conducting an in-depth and SD-relevant literature search about the Fermentation process of "Sorghum beer" which was localized and relatable with which SA learners were familiar. The group showed evidence of consultation with an IK holder who had more detailed information on "Umqombothi" and its traditional importance as she was the designated Umqombothi producer in the community and everyone came to her for their ceremonial needs (DA1). This is captured below.

7. **Voice of an IK holder.**

Whether knowledge/ views contributed by IK holder was included in presentation.

Some evidence of consultation shown. Knowledge of the beer making processes, ingredients and traditional significance was offered by an IK holder and included in the presentation.

*Extract on the inclusion of the IK holder in Group One's presentation*

**(iii) Micro-teaching Observations: Natural Sciences unit of work Grade 6: Inorganic fertilizers**

Group Five's presentation was observed at 11 am on 07/08/2021. The content as outlined in their PoE focused on the importance of fertilizers to the soil and farming practices. The extract below is from the OS which was used to observe the main components of the unit of work.

<b>1. Subject matter content</b> (Topic/Focus area being taught)	Focused on different fertilizers. Soil and Agriculture. Soil and fertilizer preparation. The theory and practical aspects of fertilizers.
<b>2. Outline and explanation of colonial elements in the unit of work</b>	A few references made to the colonial ideologies that dominate the unit of work taught. Only industrial fertilizers produced using Western industrial machinery was included in the content. People of Western descent were included in textbooks.

*Extract of Subject matter and explanation of colonial components in the unit of work on fertilizers (OS5)*

The action taken by Group Five was based on drawing on research about indigenous technologies linked to soil types and the use of fertilizers. The approach they used was leveraging indigenous ideas to make the soil more fertile through teaching using indigenous pedagogies like "Debates" while retaining the content necessary as well as the Euro-Western examples of fertilizers. Below is the extract from the OS highlighting the observations made relating to this.

<p><b>3. Evidence of research and an informed discussion. Use of readings, articles etc.</b></p>	<p>Evidence of research, use of readings and connection to the CAPS document was shown.</p> <p>Teachers stated that they spoke to an IK holder about soil preparation and use of soil fertilizers. More detail on their research processes were needed. Resources were lacking.</p>
<p><b>4. Evidence of decolonization with the use of indigenous knowledge in teaching phase of lesson</b> (Subject matter, evidence of preparation, examples and references used in the explanation of content)</p>	<p>The group included the use of indigenous forms of fertilizers during the presentation of their unit of work. They did not just focus on Euro-Western (industrial) soil fertilizers in their presentation.</p>

*Extract from OS on the research and decolonial exercises by Group Five*

The actions that Group Five took showed a commitment to exploring indigenous forms of fertilizers which when taught to learners will add value to their learning. It was evident that a more detailed account of the research they conducted was needed. As this was a presentation of how the unit of work on fertilizers would be taught, it was expected that the group would be able to make additions to this when implementing the lesson in a classroom setting (FN - 07/06/2021).

Decolonisation of the unit of work process was further enacted by including a definitive voice of an IK holder in the unit of work and the presentation. Group Five planned to allow the IK holder to play an active role in the teaching of the unit of work.

**7. Voice of an IK holder.**

Whether knowledge/ views contributed by IK holder was included in presentation.

The IK holder, called the elder in the presentation will be brought to the classroom and show learners indigenous ways of preparing fertilizers.

The IK holder to teach the practical aspects of fertilizer preparation to learners.

The female elder Group 5 spoke to said after harvesting maize corn people would chop down the maize straws and leave them covering the ground. The

*Extract from OS5 on how Group Five planned to include the IK holder in the teaching of the unit of work on Fertilizers*

The active role that the IK holder plays in planning to enact the school curriculum when leveraging IK to address SDGs shows a commitment to the engagement process but also ESD. This understanding and relationship between members of the teacher group came through a practical commitment to engagement and enactment of a decolonial form of the curriculum.

**(iv) Micro-teaching Observations: Mathematics unit of work Grade 6- Geometric patterns**

Group Two presented their unit of work on Geometric patterns to the science and mathematics Honours cohort. This presentation was observed by the researcher on 05/08/2021 at 10.00 am. Teachers presented work that resonated with the ideas of the IK holder with whom they had

collaborated. The subject matter that the group focused on with colonial elements was observed and presented. An extract from this is presented below.

**2. Outline and explanation of colonial elements in the unit of work**

The examples like match sticks and "die" to explain Geometric patterns was used. Games from Euro-Western contexts were used as pedagogical innovations. The authors of the textbooks used to teach the section were White males.

*Extract on the colonial elements present in Grade 6 Geometric patterns*

The extract above from Group Two's OS (Appendix A) reflects what was presented in the PoE. The group highlighted that the examples of the "Die", "Matchsticks" and "Dominoes" in the content on Geometric patterns reflected colonial underpinnings. The starting point for their action was to first research IK that could relate to the topic and consult the IK holders they worked with. I was able to observe the following relating to the research that Group Two conducted which is shown in Figure 52 below.

**3. Evidence of research and an informed discussion. Use of readings, articles etc.**

The presentation was based on information from internet searches, speaking to an IK holder who worked with traditional beadwork and speaking to an Artisan who works with beadwork.

The group presented pictures of beadwork, indigenous mats and paintings

*Extract from OS on research and engagements with IK holders observed from Group Two's presentation*

The active inclusion of IK that related to their selected unit of work meant that Group Two was able to commit to changing the unit of work to reflect, a more decolonial form of the curriculum that would resonate with learners in a SA context (Lebeloane, 2017). Figure 53 below shows the indigenous components in the presentation that I was able to observe using the OS.

**6. Evidence of focus on the use of leveraging indigenous knowledge**

(Relevance to South African learners' contexts? Reflects de-colonial, indigenous ideologies?)

IK holder in the presentation challenging who is seen as a holder of valuable knowledge related to Geometric Patterns. Groups of learners to look at beadwork and identify patterns and look for patterns. Excellent Activity shown using beadwork. Links the beadwork to the concepts and Mathematics.

The use of traditional Zulu beadwork, crafts and paintings. The cultural significance of tradition beads and the arrangement and color which signifies and gives a message.

*Extract from Group Two's OS on the use of IK in the unit on Number Patterns*

The focus on African arts and crafts and indigenous shapes were drawn upon by the group to decolonise the unit of work. Indigenous knowledge was leveraged successfully.

## **Appendix B1: FGI Template (Interview Questions)**

### **First Focus Group Interview (FGI) for science and mathematics Honours students**

Honours students through the use of the Honours module materials will be introduced to the colonisation/decolonisation and SDG phenomena together. Relevant readings were given to teachers to set the tone of the study at hand.

Before teachers engaged with the module topics related to decolonisation and addressing sustainable development, an initial discussion on colonisation and decolonisation concerning ESD ensued without probing any perspective. This orientated students' thinking and stimulated conversation. I included follow-up questions which were asked after teachers answered initial numbered questions. This created more of a dialogical engagement.

1. What does colonisation mean to you? Who were the colonisers? What did they do? How did colonisation influence peoples' education in the past in SA? Do you think it influences what and how we learn currently?
2. What is your understanding of decolonisation and decolonisation of the curriculum? What implications does it have for teachers like yourselves?
3. In your view, what role does colonisation have to play in sciences and/or mathematics education?
4. Is there a link between decolonisation and indigenous knowledge? Elaborate.
5. Is sustainable development something that you are aware of? What does SD mean in the South African context?
6. Do you know of the Sustainable Development Goals? How many are there? Can you name a few?

7. What are your roles as a South African citizen in addressing sustainable development? What then is your role as a science or mathematics teacher in addressing sustainable development? Are these two roles different? How so?

8. a Have you been trained or offered professional development related to addressing sustainable development at an institution of learning?

8. b Have you been trained or offered professional development related to addressing sustainable development by leveraging IK at an institution of learning?

9. Do you think sustainable development can be addressed through decolonising the curriculum? Explain.

10. Would you have liked to have had some professional development related to addressing sustainable development through decolonisation in your teaching? Why/Why not?

11. Would you have liked to have had some professional development related to addressing sustainable development by leveraging indigenous knowledge in your teaching? Why/Why not?

12. Do you address sustainable development by leveraging indigenous knowledge in your teaching?

**Second Focus Group Interview (FGI) for science and mathematics Honours students (Six teachers). This took place after teachers had engaged with the science and mathematics Honours module and completed their group presentations on using the curriculum to address SDGs by leveraging indigenous knowledge.**

1. What expectations related to professional development did you have of the Honours module? Explain.

2. Did you have any expectations related to decolonisation and the use of indigenous knowledge to address Education for Sustainable Development from the Honours module? Explain.

3. Did the Honours module you studied offer any professional development related to decolonising the curriculum? Elaborate.

4. Did the Honours module you studied offer any professional development related to addressing sustainable development? Elaborate.

5. What professional development related to leveraging indigenous knowledge to address the sustainable development goals in the school curriculum is offered in the Honours module?

6. Is it difficult to address the Sustainable Development Goals through the Science and/or Mathematics curriculum? Explain.

7. What challenges do teachers encounter when working with addressing Sustainable Development Goals in the school curriculum before you engaged with the Honours module?

8. Explain if indigenous knowledge can be leveraged within the science or mathematics school curriculums. Can indigenous knowledge be leveraged to address the Sustainable Development Goals within the science and/or mathematics curriculum?

9. Please share your experiences of working within a group to complete your PD task.
  
10. How were your experiences working with the indigenous knowledge holder? Did you obtain any insights related to leveraging indigenous knowledge to address the Sustainable Development Goals? Please elaborate.
  
11. What do you think about including indigenous knowledge content and knowledge from the indigenous knowledge holder in this task?
  
12. Which Sustainable Development Goals did your group address? How did you do this?
  
13. What types of strategies did you use when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum?
  
14. Why did you use these strategies? Explain.
  
15. Was it difficult to leverage indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum? Please elaborate.
  
16. What were some of the challenges related to leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum that you encountered?
  
17. What factors are obstructive or enabling when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum? How did you respond to these factors? Please explain.
  
18. How would you describe your engagement in leveraging indigenous knowledge to address the Sustainable Development Goals within your group?
  
19. Describe your professional development through studying the Honours module.
  
20. Can you elaborate on the professional development you have gained in decolonisation, indigenous knowledge, and sustainable development?

21. Would you recommend leveraging indigenous knowledge to address Sustainable Development Goals within other subjects? If so, which subjects?

22. How has participating in this project developed your Science or Mathematics and professional development skills?

## **Appendix B2: FGI Transcripts (FGI1 & FGI2)**

### **First Focus Group Interview (FGI) for science and mathematics Honours teacher participants before studying the Honours Module**

I included follow-up questions which were asked after teachers answered initial numbered questions. This created more of a dialogical engagement.

#### **6 participants**

**Presh**

**Lee**

**Nicki**

**Thobisa**

**Samuel**

**Gift**

**1. What does colonisation mean to you? Who were the colonisers? What did they do? How did colonisation influence peoples' education in the past in SA? Do you think it influences what and how we learn currently?**

**Presh:** So, colonisation to me means the violence and the atrocities that were inflicted on countries in Africa and Countries around the world by the Europeans and the colonising countries. They basically raped our country and they took all our resources and enslaved our people. We are still recovering from the effects of apartheid; I mean even though it happened decades ago we still see the effects up until today. It is not going to stop next year; it will continue into the future. That's what I have to say.

**Nicki:** I think to add onto what was said, I think it was also an invasion of culture and it was political control over indigenous people and yeah it definitely influences how we currently learn because as it was said it is like 20 years later and we are still feeling the effects of it in our education system.

**Samuel:** The passing or influence of Western Knowledge. Mainly to impart that specific knowledge unto people they deem inferior. The European, Dutch. Influenced the people of the country in an inferior way, to think in that path of knowledge. Lowered the standard of indigenous education and filtered out indigenous

knowledge from the country. Yes, it does affect us today, it does not allow us to understand and value our knowledge.

**Thobisa:** My understanding of colonisation is more, for example, religion-wise, where our people were told to let go of their belief systems where they were practicing and tending to the ancestors and stuff. They were deemed like demons and stuff and they increased Christianity. As a way to control the way people see and do things in order for European people to get the wealth and resources of our country. As the other colleagues have indicated with the issue of education, they used that to put us into inferior positions. Giving us enough education whereby we can work for them but not enough education to think for ourselves and use what we have in terms of the traditional knowledge and ways of doing things. Which is indigenous knowledge. Indeed, it is affecting us currently because if you look at the news which the issue of Christianity you see some glitches and you be like is this the proper way of doing Christianity with the stories that are happening, you also see with education, the syllabus, the curriculums, you still find some areas that represent a group of people, the elite ones, the white people as compared to the other people. It is an ongoing, continuing fight. Thank you.

**Gift:** Colonisation means the domination and control of people. I can say mostly the control and domination of the mind. The colonisers were and still are the whites and Europeans. They brought their religion and their knowledge and subdued the views and ideologies of black people, often using violence and fear as means. Colonisation influenced peoples' education by political means, making everything colonial seem right and everything indigenous seem wrong.

The legacy of apartheid and colonisation still exists in the way people treat each other and the knowledge that is taught at school.

## **2. What is your understanding of decolonisation and decolonisation of the curriculum? What implications does it have for teachers like yourselves?**

**Presh:** It took a while for me to see the uhhh importance of decolonisation. In the beginning, I was like what are you talking about? Now I can see it, I can see how colonised our curriculum is. So, decolonising the curriculum is to bring it back to our African roots, not only African but the global south. Because right now our curriculum is dominated by the global north. And we are not just consumers of knowledge, we also produce knowledge. So decolonising means giving credit to the other countries that were left out in the past and the implications for teachers mean that we as teachers have to be so critical because before this, I honestly couldn't see it but you have to look at it with a critical eye. Examine what you teaching and what you are giving off to your students. It means that we have to be so critical about what we teach and we have to be inclusive and think out of the box and go the extra step. We have to include other indigenous knowledge and knowledge from other cultures, not just the west. Because our textbooks don't give it to us, what we're required to teach with is all colonised, and this is a new thing we have to come up with on our own. It is not mainstream as yet, it's a big responsibility on teachers.

**Samuel:** Decolonisation means the removal of colonial ideas/ integration of indigenous knowledge and removal of solely western knowledge from curriculum content covered in the education systems. It places some form of responsibility for teachers to teach in a different way, or context that they were taught to teach in, develop a way to impart indigenous knowledge into the classroom, yet still keep to content and maintain curriculum coverage.

**Thobisa:** Understanding of decolonisation, is the removal of solely colonial ideas and then for the decolonisation of the curriculum, trying to integrate indigenous knowledge into the curriculum, aside from the western knowledge that is imparted in the curriculum. Obviously, we can't completely remove western knowledge but we can use it as a framework and include indigenous knowledge as well. And implications it places a form of responsibility for teachers to teach in a different way or context to what they were actually taught in university. Because for most of the courses we don't really cover decolonisation in content we generally go with the content that needs to be covered in school and we need to be teaching the learners. Also, it places an emphasis on us to impart indigenous knowledge into the classroom with still maintaining that content and maintaining that curriculum is covered adequately.

**Gift:** Decolonisation is a process of redress based on correcting the evils of the past. Decolonisation of the curriculum should be based on reviewing what is taught and how it is taught at schools in order to centre the learner and their knowledges. This exercise would imply that teachers consider what they teach and how they teach it. It means teachers bringing African knowledge to the fore.

### **3. In your view, what role does colonisation have to play in sciences and/or mathematics education?**

**Presh:** I think colonisation serves to maintain the status quo. To keep the developed countries up there and the developing countries down here. Colonisation for me seeks to maintain that. Because still here, we still look up to west like wow, it is another world, we aspire to be like them. But you know, it is not about self-sufficiency and improving us as a nation. I'm not sure if I am answering correctly but that's what it means to me.

**Nicki:** Science and mathematics are subjects that are so important to a country. It is so important for our countries especially, developing nations to progress scientifically and mathematically but if these subjects continue to be colonised what hope do our students have? It is not relevant to them, there is no hope. So, we need to change it.

**Samuel:** I just want to say for me it forms some sort of standard for us because without it you could say that we wouldn't have knowledge about innovations and stuff. Even though our country does come up with their own ideas and own innovations and stuff it still forms a kind of standard that we can try and strive towards and let's say build towards achieving. Also, if you look at science and mathematics but more specific because I teach science its more about how science has its own universal language and something that we need to I don't know how to say it, something that we need to acquire and be able to interact with not just people within our own country but also with the world itself.

**Lee:** I think they made a mistake when they said colonisation, I think the right question should have been in your view what role does decolonisation have to play in sciences and/or mathematics education? I don't think it would promote colonisation but if colonisation would be promoted, if it was the right question, colonisation would have to note indigenous knowledge as well. But I act I thought this was an error or something.

**Thobisa:** Can I come in? The role that colonisation plays in science education. I will say it creates the impression like the other speaker said. Whatever that we do, whatever that we produce in terms of knowledge, innovations in Africa or in South Africa we have to look up to the western world, how are they doing it? And even if we produce something, we still need to give it to them for approval and everything. So, it creates the impression that the western people are like God of science and then whatever that we do we have to bypass them and it creates this false idea that as Black people if I may put it like this, or African people we are unable to think for ourselves and do anything for ourselves. It also perpetuates those little areas for the western people, the knowledge that they have created to stay dominant forever and forever. So, their legacy on that side continues while other people just fall off, thank you.

**Gift:** From my experience as a learner and now a teacher. It is evident that much of what is taught in science and mathematics textbooks are colonised form of knowledge. There is the blatant exclusion of the knowledge found on the African continent. Colonisation has influenced the way science and mathematics is perceived, the examples found in the textbooks, and the scholars that are centred in those subjects. This could be one of the reasons why South African learners tend to struggle with science and mathematics.

#### **4. Is there a link between decolonisation and indigenous knowledge? Elaborate.**

**Presh:** Yeah, I think there has to be a link decolonisation and indigenous knowledge. Because we have to go back to what happened before colonisation and that was our indigenous knowledge. So, in decolonising our country, we have to remove all, well not remove but you know cleanse our country of all these foreign, dominant ideas. And give importance and credit to what our people had which is considered indigenous knowledge. I think there is a strong link if we talk about decolonisation we have to go back to the basics and the basics are indigenous knowledge.

**Samuel:** I'd say yes there is a link between decolonisation and indigenous knowledge. Also, at the same time, when we think about colonisation, we prefer to think that even though colonisation did take place, you still find that there is a lot of communities you could say are not colonised. In a sense that over the generations that have passed, most of them adhere to their indigenous knowledges. So, in that sense, research can be done into those communities that you know still value the indigenous knowledge that has been passed on through their generations. And impart that onto or for the benefit of using it into integrating it into education as well.

**Lee:** Yes, there is a link between the two. When it comes to indigenous knowledge when we trying to decolonise the curriculum or a country it is important to involve indigenous knowledge of that country. As it teaches them the importance of that country, that place or continent, or whatsoever. Let's say they have to

teach us about African ways of doing things not only just the Western ways because we won't be just removing the western ways, we will be incorporating indigenous knowledge, which in most cases our indigenous ways of doing things are usually cheap and they don't have to use any technical or expensive objects.

**Gift:** Yes, there is. Since colonisation meant the removal of African and indigenous knowledge, the opposite should be true for decolonisation. To decolonise means to return those components that were removed from African society during colonisation. One of those components is indigenous knowledge.

##### **5. Is sustainable development something that you are aware of? What does sustainable development mean in the South African context?**

**Presh:** I was only made aware of these goals recently. I had no idea of its existence before. I am so glad that it was brought to my attention because it is brilliant and in the South African context, I feel like well not only the South African but contexts similar to South Africa we have to strive to achieving these goals so that we can develop our country in a sustainable way. I mean the world is developing and the world is progressing but so much of it is not sustainable and its greedy and its selfish but if we can develop Africa in a sustainable way then we can ensure the continuity of the future generations. So, what it means to me, it means that we have to come together to achieve these goals for the future generations of Africa.

**Thobisa:** I was aware of sustainability; I sometimes teach Agricultural sciences so in some concepts when I teach farming systems and methods, they will say that we must always strive to look for sustainable ways of farming such that we keep our resources intact for future generations. I was aware but now it has broadened everything now to say that every concept that you teach, maybe every topic that you teach it might be related to a Sustainable Development Goal. And in terms of our South African context, I think as the last speaker indicated, you know with the industrialization, more ways producing things quicker, doing things quicker, more plastics with the issue of pollution and stuff, so having Sustainable Development Goals will assist so much to clean the environment and produce clean energy and stuff, thank you.

**Nicki:** Okay, so, yes, I was aware of it I think within the context of South Africa, it is not just building upon our environmental systems and stuff it is also mainly based on our human dignity and social equity-like for example just having the basic needs of people met, for example, drinking water and things like that. And at the same time, it's also to sustain the ecosystem and the natural resources we have efficiently. For example, like our coal system is not the best way at the moment and I think that is something we need to consider as well.

**Gift:** I am aware of such a concept. How it is addressed, its relevance to education and the South African context is not something that I am aware of. It was never taught to me during my undergraduate studies or

any other training. I got information about this from mainstream and social media platforms and educational conversations with other teachers.

#### **6. Do you know of the Sustainable Development Goals? How many are there? Can you name a few?**

**Samuel:** Well, I can say that now I know of them because we had to research them, I think there are 17 but I can't name all of them. I can just speak about two. It was SDG 6 I think to ensure availability and sustainable water and sanitation for all. That could also work together with goal 13 which was taking urgent action to combat climate change and its impacts if we try to interlink it there.

**Nicki:** So, I do know the Sustainable Development Goals obviously not all as it was said there are 17. A few that I am thinking of that we did for something else; I think it was climate action or climate change and quality education, and the water one, I think that's the ones I can remember.

**Presh:** So, I also say 17 goals, a few I can remember is about protecting life on land, life in water, gender equality, No poverty, No hunger, quality education, sustainable communities, and coming together to meet the goals. I think that's all that I can name right now.

**Thobisa:** I don't remember the goal number but there is the other one about partnerships and working together that is the one that I mostly know. I forgot the other ones. The other ones they have mentioned, yeah.

**Gift:** I have heard about the goals. There are a few of them but unfortunately, because of the lack of knowledge and awareness of these, I am unable to name them.

#### **7. What are your roles as a South African citizen in addressing sustainable development? What then is your role as a science or mathematics teacher in addressing sustainable development? Are these two roles different? How so?**

**Presh:** I think perhaps, roles overlap, as a South African citizen it is our responsibility to try and meet these goals and as teachers, it's our responsibility to educate our pupils about these goals and try to foster the qualities in our learners. So, these roles are different but, in a way, we are all responsible for these goals whether you're just a citizen or a teacher, we are all responsible for these goals whether it is following these goals in every action you take or whether is educating your learners about you know just being aware of these goals and also like inculcating this sense of responsibility for your planet and your nation.

**Samuel:** I was just going to say with the roles, as a South African citizen we have a role to try and play our part in addressing the SDGs, and then as a science or mathematics teacher, I think passing on the knowledge about sustainable develop is a bit more important there. But at the same time, they have to link up together. So, I would say that although the roles are different because it is you on one side trying to do your part, and then on the other side you trying to get your learners or people at school to try and play their part. It is still

interlinked because you obviously can't be teaching them about sustainable development or trying to impart the knowledge if you not doing it, you know by yourself. It's like practice what you preach in that sense. That was my response.

**Gift:** Sustainability is the responsibility of every South African citizen. As a mathematics teacher, I believe my role may be to teach my learners about this through the topics I teach and my subject as a whole. I think the role of a teacher to addressing sustainable development is different to that of a normal citizen because I have the responsibility of teaching the next generation of citizens about sustainable living. Unfortunately, I am not able to address SDGs in the curriculum due to lack of knowledge.

### **8.a Have you been trained or offered professional development related to addressing sustainable development at an institution of learning?**

**Presh:** I have not been offered any professional development for sustainable development. Like I said I haven't even heard of it before.

**Samuel:** The same here, I don't think I was formally made aware or trained in addressing sustainable development. Maybe it was imparted somehow through the content but not formally. I think Cat might be able to speak on this because she does do work with an academic in the institution. So, she might have an idea on this.

**Nicki:** Thanks, no I haven't been offered professional development like specifically (about sustainable development) but yeah as he said there were, by the way, things that were mentioned, it wasn't like something emphasized on.

**Gift:** No, I have not.

### **8.b Have you been trained or offered professional development related to addressing sustainable development by leveraging IK at an institution of learning?**

**Presh:** I have not been offered any professional development for sustainable development by leveraging indigenous knowledge. Is that even possible?

**Samuel:** Same here, I was never aware or trained in addressing sustainable development through the use of indigenous knowledge. These two concepts indigenous knowledge and sustainable development were never used in the same sentence.

**Nicki:** Not at all.

**Gift:** No reference to indigenous knowledge and sustainable development were made.

### **9. Do you think sustainable development can be addressed through decolonising the curriculum? Explain.**

**Presh:** I honestly think it is a bit of a reach. Like I haven't even made the link before. I think sustainable development can be addressed through other means not necessarily through decolonising the curriculum. I

do think it's sort of like killing two birds with one stone because they're both goals. Decolonising the curriculum and addressing the SDGs, I mean those are the goals. And if we can do it through the same means then why not? So, I do think it can be, but I do think it is a bit of a reach. It's a lot of effort to link the two. In my personal experience for mathematics and in the mathematics field. It's a lot of effort, maybe if we were provided help with that it wouldn't be such a hard thing to do. It definitely can be done, but as teachers, we have so much going on, we need that support.

**Nicki:** Yeah, I agree with what was said. Sustainable development goals as a whole is a global thing it is not necessarily our country or developing countries. It is not specifically dominated by western knowledge to say. It can be done, but I don't think it specifically falls under decolonisation.

**Thobisa:** I think sustainable development can be addressed through decolonising the curriculum because decolonising the curriculum we usually revolve around like indigenous knowledge. So, if we take that understanding of decolonising and saying we are using indigenous methods and understandings. Using traditional methods are always cheaper than the other ones. They are always eco-friendly, they do not damage anything, we do not process anything. And it's always about a group of people working together when practicing these indigenous methods. So, we can link and promote SDGs through that. I still agree with the first speaker in that it is not always about using decolonising curriculum to promote sustainable development, there might be other ways because they are both two big and important goals, thank you.

**Gift:** My lack of knowledge on sustainable development makes me unsure of the response. I do think that using African knowledge may lead to us living more sustainable lives, therefore decolonising of the curriculum should be able to contribute to sustainable development in some way.

#### **10. Would you have liked to have had some professional development related to addressing sustainable development through decolonisation in your teaching? Why/Why not?**

**Samuel:** I think, yes it would assist. Because, going back to what Precious said, having that support amongst everything else that we have to do or that's expected of us. I think that that extra development would have allowed us to maybe plan better or be able to impart knowledge on sustainable development through using decolonisation as well. That's my reasoning.

**Presh:** This is such an eye-opener honestly. Yeah, I would have loved to get some professional development regarding this issue. I am passionate about both these causes and I think it would be great to be equipped with the skill that would allow me to implement this in my teaching.

**Thobisa:** Can I chip in. I think like the others it would be much nicer and easier to have like they develop us with the sustainable development and doing that through decolonisation. Sometimes I look at the way I teach and I do things in class. And the way I understand things to make learners understand, sometimes I will do some of these things but not aware that I am doing them. If like I had professional development I could have emphasized more. I do remember some examples I was talking about decolonisation in passing

but not conscious enough that I am talking about decolonisation. Like I have this level of understanding, like currently, right now.

**Gift:** Yes, I would have. Any training or professional development based on sustainable development based on my teaching would have benefitted me. As a South African teacher, if this could be done through decolonisation, I would be even more enthusiastic about it.

**11. Would you have liked to have had some professional development related to addressing sustainable development by leveraging indigenous knowledge in your teaching? Why/Why not?**

**Presh:** How is this different from the previous question? Because decolonisation is about incorporating indigenous knowledge. Personally, I feel like the questions are similar because decolonisation to me is about indigenous knowledge so, the answer again is yes, I would like the professional development.

**Samuel:** I think with this question here, in some ways it is slightly different from question 10. Because here you may be looking at how you as a teacher could be leveraging IK. When looking at 10 that could be professional development, with sustainable development and decolonisation in general. But here, using the word leveraging, getting professional development on the methods that you could use, because we as teachers generally like when we plan lessons and stuff, we generally don't use methods of leveraging indigenous knowledge or we don't feel like it is important to leverage indigenous knowledge into the lesson. So, I think if we had that professional development then in a sense, we will be able identify with the methods and techniques that we could use in our lesson planning as well.

**Nicki:** Okay I am just going to answer the question and not look at the difference between questions 10 and 11. Yes, I would like professional development because there is so many things that I don't know myself, and for us to incorporate indigenous knowledge may be difficult because I know for a fact that asking questions, like when people ask me stuff, I don't even know those things. So, at a professional level, I think that would be beneficial for all and our students.

**Thobisa:** Like the other speakers, I would have loved like professional development and training of some sort, because when I want to leverage indigenous knowledge from people I was focusing on the use of fertilizer, like traditional ways of using fertilizers. Sometimes it is tricky to take like a science concept then try to link it to an indigenous knowledge and ask the right questions, the right way for her to give you the right answers if I can put it like that. So, in that way if we had a training, we may have techniques like we have teaching strategies, we may have strategies to implement this. I don't know if this makes sense.

**Gift:** Yes. Indigenous knowledge is very important to the South African identity. Any conversation about decolonisation should be focused on the use of and retrieval of indigenous knowledge. In the Zulu culture we respect and care for the natural world, this is how our indigenous knowledge is linked to the environment. When talking about sustainable development I do believe that I should have had some professional development that draws on the indigenous knowledge on my country.

**12. Do you address sustainable development by leveraging indigenous knowledge in your teaching?**

**Presh:** It is very limited. I do sometimes discuss indigenous structures when I teach shapes in mathematics. I do speak about issues like poverty and unemployment as well, but not in detail.

**Gift:** Not as much as I would like to. In some topics like respiration, one may speak about traditional foods and rural markets. But I do not do it as much as I could.

**Thobisa:** I sometimes teach Agricultural sciences and discuss farming technologies, fertilizers and traditional crops like sweet potatoes. I think it is limited to those topics. There are other topics where we cannot leverage indigenous knowledge to address sustainability issues.

## **Second Focus Group Interview (FGI) for science and mathematics Honours students after engaging in PD with the Honours Module.**

**I included follow-up questions which were asked after teachers answered initial numbered questions. This created more of a dialogical engagement.**

### **6 Participants**

<b>Precious</b>	<b>Dwayne</b>
<b>Cat</b>	<b>Essy</b>
<b>Sbu</b>	<b>Will</b>

### **1. What expectations related to professional development did you have of the Honours module? Explain.**

**Precious:** I expected to learn content that would help me to be a better teacher because my goal was how can I better help my students because their needs are specific and individualized. So that's what I was going in expecting, how can I be a better teacher and how can I serve my students better. Get the message across better, I think that my aims were achieved by that module.

**Cat:** I agree with that, I am going to have to say that it was definitely about developing ourselves as teachers. When I first looked at the term curriculum development, I thought it would be like more of a better understanding of the curriculum and how we go about doing it and getting things done in terms of the needs of the students and the different ways we can do it.

**Sbu:** Yeah, I think it is more or less the same, it was all about the content and the pedagogy so yeah.

**Dwayne:** To be exposed to a deeper understanding of the curriculum. To be made aware of discrepancies in the curriculum. To acknowledge curriculum development in terms of inclusion of indigenous knowledge. To understand how curriculum analysis is conducted. All of the above expectations would enable me to have a wider perspective on the current curriculum and enable me to interpret the curriculum in accordance to the relevance in our current era. Enable me as a teacher to enhance the curriculum through techniques such as inclusion of indigenous knowledge – inclusion of new knowledge systems that are able to integrate and influence better teaching practices.

**Essy:** I had expected to learn about how to challenge the existing science content and improve using right ways. Expected to be developed in professional ethics also expected to interrogate science curriculum to solve problems hindering effective learning in agriculture.

**Will:** I expected to develop as a teacher and learn about the curriculum and how to better my professional practices.

## **2. Did you have any expectations related to decolonisation and the use of indigenous knowledge to address Education for Sustainable Development from the Honours module? Explain.**

**Sbu:** (Laughs) To be honest, from my side, I wasn't aware of the decolonisation part, it was my first time dealing with it. So, I didn't expect anything, but then in terms of indigenous knowledge. Yeah, I did have some ideas but decolonisation I just only thought about Apartheid and so on. I didn't think it has got a positive effect towards delivering of the curriculum.

**Cat:** Me as well, I didn't, I knew what decolonisation was in terms of the education field but I didn't expect it to go so in-depth and the things that we miss out in our own studies and how we can help so many children in different ways when we actually consider to include everything and everyone around us. I mean in terms of indigenous knowledge I did know what it was about but it never really crosses my as much as it did now in terms of actually including it in all our topics or certain topics. That it is possible.

**Precious:** For me, I was aware of decolonising the curriculum because I think the first module, we did with the lecturer we had an assignment on that, so I was aware of it. I didn't expect to do it again in this module and when I first saw that we were going to do it, I was a bit like, ohh... come on again? Because honestly, I didn't get it but I am glad that we did do it again because the second time around I finally got it. I finally saw the bigger picture. Sorry, I didn't have any expectations for them and I also didn't know or haven't even heard of the SDGs. So, I am really glad that I was introduced to that because I think it is so brilliant.

**Dwayne:** Yes, I wanted to understand the way in which myself, as a teacher could break down current curriculum content and integrate indigenous knowledge into my lessons. I further expected to be made aware of what techniques would be viable to assess current teaching methodology, and how these techniques would surface inequalities represented in the curriculum.

**Essy:** I had expectations regarding using indigenous knowledge to teach agriculture because I have a strong belief that Agricultural sciences is what we practice at home and learners must bring their home knowledge to learn. Also, I must take them to village to learn. But it was not direct about addressing sustainable development.

**Will:** Because of the nature of education and the various colonial forms of education that exist in the South African curriculum, I would say no. Indigenous knowledge and sustainable development is not something that our education system focuses on. This isn't different in higher education; therefore, I was not expecting it.

## **3. Did the Honours module you studied offer any professional development related to decolonising the curriculum? Elaborate.**

**Precious:** A hundred percent, like definitely for me. Because now when I am looking at my curriculum, when I am looking at the CAPS document to teach and with my textbook, it is all with a much more critical eye. You know, I find myself analysing what is in the foreground, what is in the background, symbolism and I try to incorporate that in my teaching, and when I do teach, I personalize and I make the questions more relevant to my students. I definitely approach the curriculum with a more critical eye. I am much more aware of that now.

**Cat:** I am going to say yes as well, we definitely, this whole module in fact has definitely helped me to analyse things much more differently and it helped me to analyse and to develop my own critical thinking in so many aspects. When we teaching and working with different students there are a lot of things, we take into consideration now compared to what we did before.

**Sbu:** And also bring in the practicality of the subjects we teach more related to the South African context other than being Eurocentric. In terms of selecting the examples from the textbook and stuff like that and

developing other examples that are more of decolonised examples. Like African examples, South African examples, and stuff like that so yeah. No, we are more observant to that, because at times I wasn't aware that at times when I make some examples, I leave other students behind but now yeah, I am more observant.

**Dwayne:** Yes. It made me aware of the structure of the curriculum. It also made me aware of the role players in curriculum development and how myself as a teacher, could surpass such role players by being an instrument for change through teaching methodology used in my classroom. It also provided me with the knowledge of, and skills in critical discourse analysis which made me more confident in successfully decolonising the curriculum to envision and promote change towards a more relatable curriculum that can be understood better by learners within the classroom environment.

**Will:** Oh yes it did. We were taught about critical discourse analysis by our lecturers and how to identify colonial aspects in the curriculum. We also learned about how to use African and local knowledge within the curriculum to decolonise it. We did this by doing research and speaking to indigenous knowledge holders.

**Essy:** Yes, a lot it did. What I loved the most was I was doing the decolonising in my assignments. Taking a topic and try to decolonise it but first, assess colonial signs using critical analysis discourse. Now when I look at a science content, I see beyond what is written, I critically assess everything.

#### **4. Did the Honours module you studied offer any professional development related to addressing sustainable development? Elaborate.**

**Precious:** It did for me because before the module, it hadn't even crossed my mind to bring to bring those type of concepts into the lesson. It really didn't, I was just focused on mathematics like you know content. The module has taught me is that it is our responsibility as teachers to bring that into the classroom because the youth is our future. And if we don't teach them sustainability from now then we going to be in the same position or even worse a couple of decades later. So, it definitely opened my eyes, it just made me like a wholesome teacher it unlocked like not only focusing on what but holistic teaching in all the different aspects of life.

**Cat:** Yes, in terms of myself, there is a lot of things in natural science especially and even geography that there are small sections, for example, water availability and climate change. Because it is such a small section in the curriculum, we usually do what is necessary and brush it off. Here we actually going in-depth helping students not just for themselves and for their future and how they address it, also to go out into the community and have that impact. So definitely, especially for Environmental studies.

**Sbu:** Yeah, for me, I wouldn't say it didn't offer any professional development, but yes, I did that task that we supposed to do but it is still much of a problem for me. I can't say I understood it may hundred percent. I am still struggling with some of it. There's not much I can say about it. I think I still have to dig deeper, to make it more understandable. Yeah.

**Dwayne:** Yes. Prior to the module, I had been unaware of the SDGs in their entirety however through working within the scope of the module, I was exposed to research on the SDGs through the module assessment. It also provided me with knowledge on the SDGs and offered me techniques and strategies to include and promote the SDGs within the classroom environment.

**Essy:** Yes. I remember we did a topic on sustainable development meaning sustainable development goals focusing on social, economic and environmental issues affect us. But we were required to use indigenous knowledge to ensure we promote the 17 SDGs.

**Will:** The module made us aware of the 17 SDGs, about Education for sustainable development and how to approach it in the South African context. Through studying the module, I was able to understand what sustainable development is and how I can contribute to it as a teacher.

## **5. What professional development related to leverage indigenous knowledge to address the Sustainable Development Goals in the school curriculum is offered in Honours module?**

**Precious:** Yeah, so we had to leverage indigenous knowledge and we had to see how can, we use that to promote the SDGs, and also promote the SDGs. And I would have honestly not made that link myself. I would have just gone about it some other way. But the module did show me that it is entirely possible to link indigenous knowledge and SDGs. I did have that mindset in the beginning, I was like why are we looking so deeply at this, you know, I didn't see it at all.

**Cat:** I don't have anything I am going to say that is going to be different to what was said, so, I am just going to agree and say yes there was a link and if it weren't for this module, the links that were developed were definitely not seen by us. But that we look at things by book, if that is the right term. If that in front of it. That's that. As teachers we definitely do need to find the link between things, in order to help improve education in general. We have that box mindset that everything is as is.

**Sbu:** Nothing to add. Please continue.

**Dwayne:** Professional development in terms of leveraging indigenous knowledge is done through placing the researcher, myself in this case, as well as other students, in a position of a procurer of indigenous knowledge through data collection strategies. This activity stimulated an interest in different sources of indigenous knowledge and required us to adopt practices that would allow us to both, engage with and equip us with techniques to leverage indigenous knowledge. Exposure to different ways to leverage indigenous knowledge.

**Essy:** We were taught about indigenous knowledge and its importance, most importantly how to get it. We were required in an assignment we choose a science concept through indigenous knowledge, to get indigenous knowledge from village elders. And use that to ensure sustainable environment.

**Will:** We were taught about the benefit of African indigenous knowledge and how they can contribute to achieving sustainable development. When we did our main task, we drew on the knowledge of indigenous knowledge holders and had to select different SDGs to address. Fortunately, our lecturers showed us how to do these and demonstrated for us.

## **6. Is it difficult to address the Sustainable Development Goals through the science and/or mathematics curriculum? Explain.**

**Precious:** It was a bit of a struggle for me. I am teaching, mathematics, and I am teaching Sixth grade mathematics. So, there's not a lot of, it's very basic mathematics and I did struggle to incorporate it but what helped was using the indigenous knowledge because with the introduction of the indigenous knowledge there is more-broader content and scope that I am bringing into the class. If it was just mathematics, it would be purely scientific and numbers but with the indigenous knowledge, I am able to talk about more topics and different topics that are relate to SDGs. So, I did struggle like if I was just doing it with mathematics, it is a bit of a struggle I am not going to lie. You have to work at it and develop it and practice. And then, with the indigenous knowledge that helped me personally. The link became clear, it was almost necessary. We needed that ink in order to address the SDGs. Without the link it was really hard for me. It definitely gave a sense of direction to what I was doing.

**Sbu:** For me, I was really struggling on the Whatsapp group, maybe I was the one most struggling in that module regarding the SDGs. Up until we had the first focus group discussion that we had it became clearer. I am teaching mathematics at a high school and to teach a topic on its own is already difficult. The focus group interview assisted us so then I was like able to start writing.

**Cat:** I am going to say no, in terms of the science part. Because with science there is a lot of topics, for example if you looking at Climate Change, Life below water, Life on Land, Clean water and sanitation and Health and Well-being, like all of that can be incorporated into the science curriculum whether it is because we studying the body or for the Heart example. If you are looking at Life below land, it can be incorporated into your water topics. Life on Land as well if you looking at Plants, it can be addressed through all of those topics. So, for science and sustainable development I think it goes hand in hand.

**Dwayne:** No. In terms of addressing SDGs, I am placed within the sciences, and therefore in relation the subject matter, I find that it is simple to incorporate the SDGs into the science curriculum as many of the goals can be found within the scope of the science field. In general, the SDGs require integration in all subjects however, I felt it was efficient to promote them through the science curriculum with respect to those that related to science and change.

**Essy:** I wouldn't say difficult but say challenging because it requires critical thinking and planning, resources and time which is always limited. And some SDGs it is not practical to apply them in a science lesson.

**Will:** Yes, it was. Especially since there was no framework or guidance in the CAPS document on how to do this. Science and mathematics as subjects are very prescriptive in nature, so addressing specific SDGs through these subjects became an arduous exercise with a lot of trial and error.

## **7. What challenges do teachers encounter when working with addressing Sustainable Development Goals in the school curriculum before you engaged with the Curriculum Development module?**

**Cat:** Time, the limitations on time to incorporate sustainable development into the curriculum, and the curriculum is quiet jam packed. So, just to add those few things it does take up a lot of time.

**Precious:** Yeah, I agree, time is a big issue because just finding enough time in a lesson to get through the content is a struggle, now I have to add in SDGs. I get the importance, so it is something I want to do. And then also, for the mathematics curriculum before I even though about the linking indigenous knowledge, I was like, where the hell am I going to fit this in? What am I going to do with Grade 6 now? Like Fraction or Grade 6 Addition and Subtraction, we still doing the basic operations in Grade 6, like how am I going to fit this in? So, that was a struggle. The time and how to link it.

**Sbu:** Yeah, I was also going to say, the fact that the curriculum is just given to us as teachers, it is not something that we as teachers develop. So, we are given to deliver it, so, you end up saying no, I do not have time. You end up struggling to be more flexible and putting in stuff that is not yet even part of that curriculum. It was better maybe if teachers were given a chance to say okay, now, you are part and parcel of developing this and that on the curriculum but now that it is given to us, like we have to teach it as it is.

**Dwayne:** I believe teachers are firstly unaware of the SDGs and the methods through which they can be integrated into their teaching practices. Furthermore, once teachers are made aware of such knowledge of the SDGs, they would then need to have knowledge of incorporative strategies to promote SDGs in their lessons which I felt I obtained through working within the module.

**Essy:** It requires critical thinking and planning, resources and time which is always limited. And some SDGs it is not practical to apply them in a science lesson.

**Will:** There isn't enough materials and time to include SDGs in each lesson. We have too much administrative work to do. Looking for SDGs that link to specific topics is hard. There isn't enough knowledge and training available to us for these processes.

**8. Explain if indigenous knowledge can be leveraged within the science or mathematics school curriculums. Can indigenous knowledge be leveraged to address the Sustainable Development Goals within the science and/or mathematics curriculum?**

**Precious:** We can, we definitely can, I mean we saw that with our task/assignment. It is possible but it is a lot of work and teachers already have a hundred and one things to do. So, I think, maybe if it was streamlined, it would be better for teachers. Like if it was incorporated in the CAPS document, like these are the indigenous knowledge topics you can use to teach these concepts. Like that would really help like any teacher on the field. Because we are doing the module now, we are engaging with it, but other teachers, they are not going to bother with that. So, it is definitely possible, because that is what the assignment showed me, I can do it, but at the same time, it took me a really long time to find an indigenous knowledge link. And I was asking everyone, what can I do to link this? And I think because I am not a very cultural person and I don't have that kind of experience in my life it was harder for me. So, if it could be streamlined and incorporated into the curriculum or maybe just have like a side document for teachers then that would really help. I think it is such an important thing to do, I mean I am saying its hard and I acknowledge that, but at the same time I really think that it is something that needs to be done for our students, for our continent and our people.

**Cat:** I had a blank moment. Yes, it can be incorporated but it is not something that can be done overnight, it is going to take a lot of time. And as it was said, it is something that needs to be included in the CAPS or in the curriculum in general because teachers really do not have the time and I know that it was addressed in one of the other modules as well but the people who do create the curriculum are not exactly familiar with what goes on in the classroom, and I think that's a big challenge. In terms of being from the teachers' side, it is not easy, like it was said before, we have access to this module, what about all of those people who don't? So, how is that going to benefit everyone if it is just a few people?

**Dwayne:** Yes, indigenous knowledge can be leveraged in the curriculum, not in its entirety, however, many current textbooks serve to incorporate indigenous knowledge into subject material but does not promote knowledge of the Sustainable Development Goals which would assist in addressing these goals.

**Essy:** Yes, it can be leveraged. But you must know who the indigenous knowledge holders are. Involve indigenous knowledge holders too in that process.

**Will:** Yes, it can be. When talking about the decolonial project at South African universities, indigenous knowledge plays an important role to this. From our professional development within the module, completion of the task and engagement with indigenous knowledge holders, it is evident that indigenous knowledge be leveraged to address the SDGs within the science and mathematics curriculum.

**9. Please share your experiences of working within a group to complete your PD task.**

**Cat:** It was good, but the issue was because we don't have that contact and it was just online, it did become challenging to just pick a certain time that we were both available and network issues of course. But, yeah, if you have an understanding with your partners, the workload that you both need to play a part in then I guess it can go smoothly.

**Precious:** I mostly worked on my own, I mean it was okay. I am a little bit of a procrastinator. So, one of the downfalls of that at times is no one's pushing you, but it was okay I could take my time. I just didn't know how the groupwork was going to work in a pandemic so. It was okay, it was tough I am not going to lie.

**Sbu:** For me, no one was nearer, I am there in a deep rural area around Msinga so it was really hard to get partners. And yeah, it took a lot of time, for me, I spent a lot of time doing this assignment, so, yeah, it was time consuming. What I will also say is that it was more of an advantage for me, when I was told that at least

the best way to attend this assignment is to first consult the indigenous knowledge holder. The place that I am living in is more of like, they do recognize their culture and stuff like that. These things of artwork, these things like paintings and stuff like that. Most people around this area live with it, so, they do these things of “Imbiza”, they do this thing “Ukumba”. Like even the beadwork, so it was really interesting to get some of the ideas from those people, but then it was time consuming.

**Dwayne:** It was a pleasant and positive experience that broadened my perspective of knowledge in terms of indigenous knowledge as well as science curriculum in general. It also provided me with insight into practices I was previously not exposed to which enriched my understanding of the community I worked within.

**Essy:** It was challenging and interesting, my group members were welcoming. And they were happy that I was included in our teaching.

**Will:** Working with my group members were both a challenge and a great experience. Challenge because we would often argue and disagree as to which topics to choose and which SDG to address. This was time consuming. It was also a great experience working with them because we got to share the work and discuss our views. Working collaboratively was really beneficial for us.

**10. What were your experiences working with the indigenous knowledge holder? Did you obtain any insights related to leveraging indigenous knowledge to address the Sustainable Development Goals? Please elaborate.**

**Cat:** It was fascinating and sad. Fascinating because they hold so much knowledge and they’ve been through so much. And, now with all this advancement in technology and people just developing. Yes, it’s a good thing, that we’re developing, it is sad because they survived for so long without all these new equipment and knowledge and for us to just forget about it, it really does along the way lose who we actually are in terms of our culture. It is refreshing for them to think out of the box and come up with solutions.

**Precious:** For my assignment, I did traditional Zulu beadwork. Then, I approached an Artisan to talk to him, only to find out that he was actually Zimbabwean and it didn’t really have a cultural significance for him. He just learnt that at a trade school, so I used him. I asked him to help me with my lesson plan and how to incorporate it into my lesson. Then the second person I talked to was the teacher at my Mom’s school. Because I didn’t know where to find a “GoGo” you know. So, I went to my Mom’s school to talk to her, and she was telling me about her history, and it was very interesting to her. I don’t think she has been asked that before, because she was very eager to tell me. You know, what she remembers of it and doing it with her family, so, I also got the sense that it is not very common anymore. So, I definitely felt like slowly its being lost through generations and yeah, it was very interesting to talk to both of those people.

**Will:** I was amazed at the knowledge and insight that the indigenous knowledge holder had. He understood my subject but also had knowledge of how indigenous knowledge can fit into the topic I chose to teach. We need to stop thinking of these knowledge holders as old, traditional people with little academic knowledge. The knowledge holder I chose was young and vibrant, he had academic knowledge but chose to be a “Sangoma” out of duty.

**Dwayne:** It was a good experience. Yes, in terms of the knowledge leveraged, the indigenous knowledge holder provided my partner and I with insightful knowledge into practices that were passed on through generations. This knowledge was used within the planning of our lesson, and therefore, allowed us to address SDGs through the inclusion of such knowledge. Through engaging with the indigenous knowledge holder, we also worked within an SDG goal which resonated with partnership for change.

**Essy:** Well, it was an amazing experience because the female elder I was working with was very rich in the female elder I was working with was very rich in knowledge about soil fertility. She used cow dung and domestic excrete, or cattle dung. She creates troughs and mix them into the soil. Another form of fertilizer is using dry hay or grass for mulching, this supplies compost to the soil. She was warm and welcoming to my learners and patient too.

### **11. What do you think about including indigenous knowledge content and knowledge from the indigenous knowledge holder in this task?**

**Precious:** It is a very important process especially in the South African context because many people come from indigenous backgrounds and survived using indigenous ideologies. The indigenous knowledge holder had information and details from their experience and socialization that were used historically and were proven to work. Therefore, I believe that since these were used before, we should draw on them now.

**Cat:** Indigenous knowledge is an important consideration for us. We find that indigenous ways of knowing and doing things were often times sustainable and environmentally friendly. The indigenous knowledge holder that my group consulted, offered valuable information and contributed to the way we viewed the teaching of a science topic to address the SDGs.

**Dwayne:** I think it was efficient and necessary. I also think that it enhanced the knowledge sources and overall understanding for learners. I think it was also a good way to envision relatable content that learners would acknowledge and understand.

**Essy:** I think it is a good idea because you get various ideas.

**Will:** I went into the meeting with the indigenous knowledge holder having preconceptions of what I wanted to include in my study. To our surprise, that was not what the indigenous knowledge holder contributed. He offered cultural knowledge that was linked to the unit of work I was teaching; the IK holder also gave us pedagogical knowledge like storytelling and narrative teaching approaches. I think the content and knowledge that he gave us was valuable and relevant to what we hoped to achieve in the curriculum.

### **12. Which Sustainable Development Goals did your group address? How did you do this?**

**Cat:** We looked at Water and Sanitation but linking it to Environmental Studies topics like Life Cycles and Abiotic and Biotic factors etc This was also linked to Life and living. The topic chosen resonates within the Sustainable Development Goals (SDG) enlisted by the United Nations (UN), namely SDG no.6 and SDG no.13 which both encourage the education and awareness on environmental factors that impact the world at large.

**Sbu:** My group worked with mathematics by looking at someone selling and focusing on the mathematical transactions taking place. Here we looked at Poverty Alleviation. I looked at SDG 1 No poverty, SDG 2 Zero hunger and SDG 5 Gender equality.

**Precious:** I linked mine mostly to SDG 4 but also Sustainable communities and Poverty Alleviation and Zero hunger. We used the following sustainable development goals: poverty (1), quality education (4), gender equality (5), decent work and economic growth (8) and responsible consumption and production (12).

**Dwayne:** Partnership for change, through working with the IK holder, Sustainable Development Goals (SDG) enlisted by the United Nations (UN), namely SDG no. 6 and SDG no.13 which both encourage the education and awareness on environmental factors that impact the world at large.

**Essy:** Zero hunger (SDG 2) and No poverty (SDG 1). Proper sanitation and clean water (SDG 6). I observed how the how the elders use waste and natural resources to fertilize soil.

### **13. What types of strategies did you use when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum?**

**Sbu:** I don't know if I get it correctly. But what I did was, I first identified the indigenous knowledge then I tried to find the mathematics in that indigenous knowledge then yeah. I don't know if I am getting it correct. Because for me, it was difficult for me to find a topic then to go on and say which indigenous knowledge can be related to this topic. But it was better if I first got the indigenous knowledge then I said in this indigenous knowledge, which topic is related to this indigenous knowledge? Then it started working.

**Precious:** I found the exact same thing. When I started it. I was like first looking at my mathematics textbook and thinking about which concept should I do, and I was breaking my head over that. Then I realized that I should first get the indigenous knowledge, then link it because you can find mathematics in so many practices. Then after I did that, so, first I found the indigenous knowledge, then I linked it to geometric patterns and then I started thinking okay, who can I talk to, to give me more insight and more knowledge? That was the strategy I used as well, the same.

**Cat:** My group, we chose a topic first and then the Sustainable Development Goal and then to the indigenous knowledge holder. That was just it for us, and then the research comes in the process.

**Sbu:** You should be doing science.

**Cat:** I am.

**Sbu:** Oh Yeah. For science your strategy I think it can work. But for us, for mathematics it was really, really difficult to do that approach. I think it differs and depends on the subject that you are teaching.

**Dwayne:** Engagement with indigenous knowledge holder, Research articles, Online forums, Journals.

**Essy:** I simply did interviews with the elder, and then observed her doing organic fertilizer also working with learners too.

**Will:** The first thing was to do critical discourse analysis in order to find the colonial aspects in the unit of work. Then I had to read about indigenous knowledge and consult with the indigenous knowledge holder to leverage indigenous knowledge. Lastly, I consulted with my lecturers and the researcher on how to link SDGs to my chosen unit of work. Research and reading was vital. Consultation within my group and with knowledgeable other was also important.

### **14. Why did you use the strategies you used when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum? Explain.**

**Cat:** Okay, in terms of the topic for us, we looked at the one that was most likely to link to sustainable development from our knowledge and what we teach. Therefore, we chose that topic, then we went to choosing the Sustainable Development Goals, thereafter we go ahead and find someone who has that kind of knowledge and who has experienced something in that field.

**Precious:** I chose those strategies because it was the only way to get my task/assignment done. I didn't know what other strategies to employ. I just, that's the only thing that worked. Was okay let us go with this.

**Sbu:** I do not have a specific reason to say why I did use it. But I think it was only the way that I could see myself out, like being done with my assignment. Because it was really difficult for me like to say. If I were to start with the topic it was really difficult for me, it didn't work at all. I ended up doing what is so called the "trial and error method". Which was okay, could I start with this? Could start with that? This one was working.

**Cat:** I think we all went with what was comfortable with us in order to reach the necessary goals of our task.

**Sbu:** Exactly. We used them because it was what we were taught in the Honours module. The lecturer emphasized critical discourse analysis and consultations with the indigenous knowledge holder and other people because this way of approaching the curriculum was relatively new.

**Dwayne:** A wider range of informative sources would provide a broader perspective on indigenous knowledge, as well as expose us to a larger scope of indigenous knowledge to work within. It also allowed for information to be cross checked and validated.

**Essy:** Using interviews only was not enough for the kids. Thus, I wanted learners to be practically involved so that they can learn little bit of skills. They can smell, touch and do at the same time.

**Will:** These strategies are researched and are proven. Our lecturers and literature motivated for these strategies and we used them. We used whatever was available for us, like the resource person, the indigenous knowledge holder.

**15. Was it difficult to leverage indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum? Please elaborate.**

**Precious:** At first it was.

**Cat:** Yes and no.

**Sbu:** At first it was, but until we found the working strategy it was then easier for us.

**Cat:** Yeah.

**Sbu:** I think it goes back to question 14.

**Cat:** Once you found that link, it was not just the surface of whatever was touched. Okay its Water and Water that kind of linkage. No, it was deeper than that. If you went too far or too or too less, it goes off topic. It is not a major difficulty, but I think that's about it. In terms of science, it was kind of smooth.

**Precious:** For me, the actually leveraging of the knowledge was easy because there was an abundance of knowledge about Zulu beadwork. Even linking it to SDGs, it wasn't hard because I felt like because of the nature of indigenous knowledge, it is pretty holistic. It was not isolated it has information and uses a lot of things. I felt it was easy to link it to SDGs, there's so many things you could link it to. So yeah, it wasn't hard for me.

**Dwayne:** No, there is a wide variety of online research that has already been conducted in regards to indigenous knowledge. Many sources of indigenous knowledge serve to connect to or achieve the SDGs.

**Essy:** It was challenging because some science concepts it is not easy or impractical to use when addressing sustainable development through indigenous knowledge.

**Will:** We did not know what to do because this type of teaching was new to everyone. Subjects like Science and mathematics are really difficult to decolonise, now to introduce the SDGs within them became more taxing on us as teachers.

**16. What were some of the challenges related to leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum that you encountered?**

**Cat:** I was about to say time.

**Precious:** For me, I didn't have a lot of experience with indigenous knowledge, be it African or Indian or whatever it was. I don't have a lot of experience with it. So, I didn't know where to start. I didn't know

practices that I could use, I didn't know rituals and ceremonies. I didn't know all about that stuff. That is what I struggled with.

**Cat:** Okay, a part from time it was definitely not having background knowledge of these topics and the links of how it does respond with indigenous knowledge.

**Sbu:** For me, it was just understanding what is sustainable development. Like the whole concept of it, I was really struggling. As far as even now, I am still struggling with it but then I think that's what made it more difficult for me.

**Dwayne:** Sometimes sources were not credible. There was often a vast amount of research to sift through. Relevance was sometimes outdated.

**Essy:** Finding the most relevant indigenous knowledge, translating the Xhosa to English sometimes some indigenous practices cannot be fully explained using English. It needed a lot of planning and time.

**Will:** Linking the topic to the SDGs were quite difficult. Finding the time and the resources to engage in this type of teaching was also a challenge.

**17. What factors are obstructive or enabling when leveraging indigenous knowledge to address Sustainable Development Goals in the school science or mathematics curriculum? How did you respond to these factors? Please explain.**

**Cat:** Not having the knowledge ourselves, like I said. By not having that background knowledge it did seem difficult to move forward. And unless you do your research and actually plan ahead. Not just look at that one question but how it affects the rest of the task. Things like that, it is not going to move forward. We have to plan and have that background knowledge and do your research. Enabling was having lecturers and the indigenous knowledge holder who understood the role of different knowledges and how it could help us.

**Precious:** I second that and also, not having access to an indigenous knowledge holder. Not having access to one. I responded to it by asking my mother, like what do I do? She works at a special school, so she has a lot of people there who I could have asked. So, she also told me about the Artisan (who served as the indigenous knowledge holder in my group) who works there and she always passes him every day, so we should try him. Just ask around and people will help. It was enabling to work within a cohort and especially within a group to share ideas and learn from each other.

**Sbu:** For me, from what I have said in question sixteen. I ended up contacting the researcher, I remember I calling towards half-past nine at night, late. And he just gave me some assistance and it was helpful, then I started working.

**Dwayne:** Bias, location and context of indigenous knowledge, we responded by looking at the information that we gathered with a neutral perspective and with the goal that we envisioned of a lesson plan that included relevant indigenous knowledge and knowledge that was credible and trustworthy. It was enabling to work within this Honours module which gave us the tools to complete our tasks of decolonisation and address sustainability. Working with the indigenous knowledge holder was also enabling.

**Essy:** Time, I used weekends for the excursion. Language, I tried translating Xhosa to English. Making connection between indigenous knowledge, sustainable development and science content, I would read, read again try to understand each concept separately, analyse and make a link.

**Will:** Finding the resources, the information and the time was obstructive to completing this task. What enabled me to complete this was having the support of my peers and the lecturers to assist in this work. The indigenous knowledge holder and the researcher also enabled me to work better.

## **18. How would you describe your engagement leveraging indigenous knowledge to address the Sustainable Development Goals within your group?**

**Cat:** Interesting.

**Sbu:** I started breathing. It was like Wow. Everything started to be smoother and understandable, it was like yeah, what I have been waiting for. It was more interesting now.

**Cat:** Yeah, it was definitely a breakthrough once you reach that moment. And I think what was interesting was that once you discuss it as a group, you look at how we all see it from different views and the different ideas of how to link it in our work.

**Precious:** I engaged, so, I did like a lot of research on the beadwork, and I found that I could use every aspect of the beadwork in my lesson plan. From the shapes that they used, the colours that they used. The material that they use, I was able to incorporate a bit of all of that into my lesson.

**Cat:** There were no arguments within our groups.

**Dwayne:** An enriching engagement that provides one with new knowledge that enhances their own critical thinking skills, as well as widens one perspective and scaffolds onto ones currently possessed knowledge to allow one to broaden conceptual understanding.

**Essy:** My part was like being a facilitator because I had to ensure that learners were behaving, elder was doing the doing most teaching indigenous knowledge also addressing sustainable development.

**Will:** It was an eye opener since much of this knowledge I did not know about. It created a drive in me to want to know more about indigenous knowledge and work better in this regard.

## **19. Describe your professional development through studying the Honours module.**

**Cat:** It was eye opening, it allowed us to see things from different perspectives and not just be looking at it from a simple point but look at everything from different aspects.

**Sbu:** I would say, in terms of planning, in terms of delivering and implementing the curriculum. I got more strategies, more methods of teaching and more ways of analysing and more ways of understanding my own learners. I was exposed to barriers and other things that could maybe be a bit of a challenge to other learners and how I could solve them. Yeah, it was really developing.

**Precious:** It made me a better teacher to my learners and it also made me a more responsible teacher. Because sustainable development is the responsibility of all citizens of our world so, now that I even consider it, it has made me more responsible. And now, my professional development, I actually understand decolonisation, now I understand it better and I feel the importance of it. And because of that I incorporate it into my lessons and into my work. So, bit by bit I am doing my part and hopefully we get to the point where all teachers are doing their part and we can see this through. So, I am so glad that had the opportunity to do this module. It almost makes me question, like why isn't this in the undergraduate modules? Because it is something so crucial for all teachers not just Honours, but even in undergraduate.

**Sbu:** And also, to add on it, I think it develops like I am now aware of what is so called curriculum. Yes, knew that there is a curriculum, know what is the curriculum, but now I understand it more deeply. The curriculum in terms of implementation.

**Dwayne:** As a teacher, I became equipped with skills that I hadn't had previously such as critical discourse analysis, I was also able to gather techniques such as those used in leveraging indigenous knowledge and my knowledge banks were greatly influenced.

**Will:** I feel like I have developed my professional teaching practice and become better as a teacher. I now am equipped to address the decolonisation of the curriculum and sustainable development in a way that is link to the school curriculum and the subject I teach.

**Essy:** I can use critical analysis discourse also use indigenous knowledge to promote SDGs.

**20. Can you elaborate on the professional development you have gained about decolonisation, indigenous knowledge and sustainable development?**

**Dwayne:** I have further understood the concepts, I have also acquired valuable knowledge pertaining to each concept.

**Essy:** Decolonisation is about removing the unfair and unjust parts of the science concept; it is about exposing the hidden curriculum matters. You must use critical analysis discourse. Indigenous knowledge is a localized knowledge which do not harm environment so using it to address indigenous knowledge is a smart move.

**Will:** I have become aware of the link between decolonisation and indigenous knowledge. I have also conscientization myself with sustainability and how these concepts can be addressed the teaching my subject.

**21. Would you recommend leveraging indigenous knowledge to address Sustainable Development Goals within other subjects? If so, which subjects?**

**Cat:** Yes, sorry I got excited. Geography. This is so ideal for Geography because there are so many aspects in “Poverty, Equality, in Water, in Recycling”, in everything.

**Precious:** Life Orientation. We can definitely do a lot of work in Life Orientation.

**Sbu:** Life Skill, what about Life Skills in Primary school. And I am not sure about Economic Management Science (EMS). This can link to Sustainable Infrastructure and Sustainable Economies.

**Dwayne:** Yes, within Technology, Tourism, Geography, Physical Sciences, Natural Sciences, Economics.

**Essy:** Yes, in Agricultural Sciences because they link so much.

**Will:** Yes, I would. I think it can be used in all subjects, the languages, the Humanities and the sciences because sustainable development is something that we should all be concerned about in all spheres of life.

**22. How has participating in this project developed your science or mathematics and professional development skills**

**Cat:** It made me cautious, more aware, more responsible. It made me realize that when you looking at students you need to take every single person and their background into account and the way you carry yourself as well. So, in terms of sustainable development goals, do you practice what you preach and how do you take that to your kids and their communities. And it helps develop us all round.

**Precious:** Mostly the same, and interaction with the researcher, he has a lot of experience with this, or just a lot of knowledge regarding the topic. So, really it helped guide us through this whole project and I think just learning from each other. That was really great. Seeing things from another person’s perspective. This is a relatively new concept, and I don’t cross many people who talk about this sort of thing. So, it was great.

**Sbu:** It was really great, for me what was the most important part was the context. Being introduced to decolonisation, sustainable development, what matters is the context. Think I got more development on that one. Whatever I am doing I make sure that it is within the context of my learners and stuff like that.

**Dwayne:** I am able to approach curriculum with a more open mind, as well as with more critical analysis and thought processes in engaging with the curriculum. I am able to analyse and interrogate curriculum to see beyond the content that is included within, and to be able to incorporate new knowledges in a successful manner.

**Essy:** Now when I teach a science concept, I address concepts like sustainable development and indigenous knowledge meaning I am not just teaching the science concept in isolation. I teach multiple things at once.

**Will:** I am not merely a mathematics teacher anymore. I am now a curriculum developer who understands critical issues related to the curriculum and I can address socio-economic challenges through my teaching.

## Appendix C: Document analysis template

**Directions: The document analysis of PoE must include the following:**

1. Group number, subject, and unit of work that this PoE focuses on

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2. Date of submission of PoE

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3. Pseudonyms of teachers and subjects taught, pseudonym of IK holder worked with

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4. Outline of the document (What documents/information is presented in the PoE)

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5a. Evidence of colonised Information identified through Critical Discourse Analysis of;

- CAPS

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- Group's Critical analysis of textbook materials

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- Other LTSM

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6a. Evidence of decolonised ideologies presented in the unit of work, (Focus on indigenous knowledge).

- Deconstruction of a unit of work in the curriculum

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- Evidence of Teacher learning from self-directed research

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- Reconstruction of unit of work

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6b. Information obtained from CDA of support materials related to teaching and learning of a selected unit of work

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7. Description of evidence of decolonised ideologies proposed by teacher group (Indigenous knowledge selected)

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8. Extent to which the reconstructed unit of work addresses sustainability/sustainable development.

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8a. How are the SDGs planned to be taught (Achieving SDGs)?

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8b. Description of learner activity presented by teacher group which incorporated IK and address SDGs (Focus on content and pedagogy)

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9. Does the unit of work focus on science and/or mathematics education that leverages indigenous knowledge to address sustainable development/ the Sustainable development goals? Elaborate on how this is done through:

- Teacher learning from IK holder (presented in the Power-point/support materials used during micro-teaching and in the PoE)

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- Knowledge of the ancestors with associated examples of decolonised activities that groups presented

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10. Discussion of Power-points slides (used in micro-teaching) showing the use of IK to address SDGs

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11. The nature and type of support materials used to plan the unit of work that leverages IK and addressed the SDGs

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## **Appendix D: Summary of Teacher Professional Development processes**

### **Teacher capacity development**

Teachers' capacity to critique the curriculum using a decolonial approach was developed in several ways. Interactive lecture presentations, self-study using selected reading material (including policy documents, and peer-reviewed articles), responses to video clips, play-reading, and role play, as these related to the following broad topics: decolonising the curriculum, curriculum development, and transformation, curriculum models, SDGs, IKS, critical theory and critical discourse analysis, were among professional development activities in which teachers engaged. Decolonisation and SD formed a part of “topic 2” which teachers engaged with during March of 2021. I attended teacher group meetings which were held with IK holders where I served as an observer (Appendix D).

Teachers were then given the following task (which is partially presented) to engage them in curriculum development which was driven by a decolonial intent:

Interrogate policy documents (CAPS) and textbooks to develop a unit of work on sustainable development which clearly illustrates how, through the curriculum, you can:

- Critically examine the content and pedagogy and locate a topic that can be used to teach at least one sustainable development goal
- Address contemporary challenges related to Sustainable Development such as poverty, food insecurity, disease, environmental degradation, emission of greenhouse gases, and pollution among others as detailed by the Sustainable Development Goals (SDGs).
- Incorporate Indigenous Knowledge into the topic/unit. Engage in collaborative learning with peers and Indigenous Knowledge holders.

You are required to develop a Portfolio of evidence that includes:

- A written account of (i) why you selected particular SDG(s) (ii) how you leveraged Indigenous Knowledge to address Sustainable Development Goal(s).
- Development of a unit of work using a decolonial lens. This includes selecting a topic, grade, specific aims and knowledge strand, a description of what and how you will teach, a description of learner activities, highlighting the integration of IK, and addressing SDGs.

Teachers then presented their lessons in micro-teaching sessions which were subjected to observation. Teachers who volunteered engaged in focus group interviews. The resulting data was subjected to thematic analysis.

Professional development activities included group engagements, lectures, and activities related to:

- (i) Teachers engaging in Critical Discourse Analysis (CDA) (of LTSM) which they were introduced to during the study of the module (FN- 01/11/2021). The CDA formed part of the document analysis method and was done by the groups only. The researcher was not involved in this activity. I offer a brief discussion on CDA below.

Critical Discourse Analysis falls within the realm of curriculum decolonisation conversation. Within the module, teachers were taught that one of the ways to decolonise the curriculum was through CDA of science and mathematics units of work. Lectures on CDA were conducted by the Honours module lecturers in April 2021. Teachers were also given a lecture, readings and trained on how to link SDGs to specific topics. Achugar (2017, p. 45) believes that CDA “seeks to reveal the hidden assumptions in received and naturalized historical accounts”. Images and texts can control how one thinks and how one constructs reality, one’s own identity, and the identity of others (Van Dijk, 2013). Achugar (2017) posits taking a critical perspective on historical discourse requires us to connect history to its place of production. Places of production produce silencing effects (Achugar, 2017). Fairclough (2013) argues that critical analysis of sources of knowledge can enable a challenge of oppressive ideologies. The science and mathematics teachers engaging in a PD programme consistently drew on CDA (as will be observed from their FGI2 responses) to identify Euro-Western colonial ideologies within science and mathematics units of work.

- (ii) leveraging IK to address the SDGs

Teacher groups were then required to

- a. complete a portfolio task, which included presenting a written account of

- (i) why you selected particular SDG(s)

- (ii) how you leveraged Indigenous Knowledge to address Sustainable Development Goal(s).

- b. develop a lesson plan. Include the information you have learnt in a topic/unit of work in the science or mathematics curriculum. Select a topic and grade, and knowledge strand. Select specific outcomes.

- c. present what and how you will teach. Describe learner activities, highlighting the integration of IK and addressing SDGs (Field Notes - 20/01/2022- NB. Information taken from the course outline).

It is important to note that there were no initial lesson plans used. Teachers selected a topic they would typically teach to their learners by looking at the CAPS document, textbooks, and support

materials they would typically use to plan their lessons (some of these are presented as extracts in the data below).

The study of the module required teachers to work in groups with an IK holder who could have been a 'sangoma', 'inyanga', 'traditional leader', 'community member', or anyone who may have had valuable and relevant IK to which a topic can be linked. This was done when teachers were given the agency to meet with IK holders of their choosing and include them in their lesson developments and curriculum discussions. The teachers were also given the freedom to consult the lecturers outside of the lecture times and the researcher whenever they needed assistance. Engagement with individuals who were interested in decolonising units of work from the curriculum to address the SDGs occurred. This could be seen as a community that consisted of teachers, various IK holders, lecturers, and researcher. These activities constituted the professional development activities that teachers underwent. The group discussions and construction of units of work to address the SDGs through leveraging IK were focused on four subject areas that exist within the study of the science and mathematics Honours module, namely, Life Sciences, Natural Sciences, Physical Sciences, and Mathematics.

#### **b. Department of Science and Innovation (DSI)-National Research Foundation (NRF) Centre in Indigenous Knowledge Systems (CIKS) Workshop – 06/05/2021**

Teachers were invited to (and many attended) the DSI-NRF CIKS workshop on exploring how IK could be used within the mathematics and science curriculums. The workshop took place on the 6<sup>th</sup> of May 2021 from 11.30 am to 1.30 pm. I was also in attendance. The CIKS is a partnership of five higher education institutions in South Africa, with its hub at the University of KwaZulu-Natal. The CIKS is a strategic instrument for implementing the National IKS Policy (2004) and facilitates the integration of IKS in higher education as a key component of human capital development and social transformation. It is through its mandated areas of research, postgraduate training, information brokerage, networking, and community engagement that CIKS stimulates a paradigm shift in the advancement of the democracy of knowledge systems. The CIKS promotes the recognition of the multiplicity of knowledge systems in the global knowledge economy, which are cultural, place-based, and complementary to mitigate against the dominance of the Western knowledge system in the global knowledge economy. As a knowledge system on its own merit, Indigenous Knowledge (IK) has its own worldview, epistemology, research methodology, and value systems. Teachers were addressed by the global South, African academics. Firstly, the director of CIKS, Prof. Hassan O. Kaya, and the Research Manager at DST-NRF CIKS Dr. Mayashree Chinsamy.

The workshop was based on highlighting the importance of the inclusion of IK holders and practitioners in knowledge production, management, and protection, which makes knowledge production, innovation, and human capital development more relevant to sustainable community livelihood and development. The focus was to break barriers between local communities, academia, industry, business, and government. To build an active citizenry through the mobilization of community-based knowledge systems in the knowledge economy and sustainable development process (DSI-NRF CIKS, 2021).

*Teachers were taken through five key points which contributed to their PD:*

### **IKS is community-based**

IKS exists within local communities and not in academic and research institutions. IK-holders and practitioners are the custodians of IKS. This implies that in the research process they need to be recognized as active participants and not as objects of the research process.

### **Knowledge is culturally and place-based**

There is no universal reality or value-free science. This calls for a paradigm shift based on the realization that we are living in a polyepistemic world, where knowledge systems are complementary rather than competitive.

### **Combining theory and practice**

The CIKS drive to excellence and relevance, through working with IK holders and practitioners, facilitates a paradigm shift in knowledge production, innovation, and sharing, by breaking down barriers between academia, industry, business, government, and local communities.

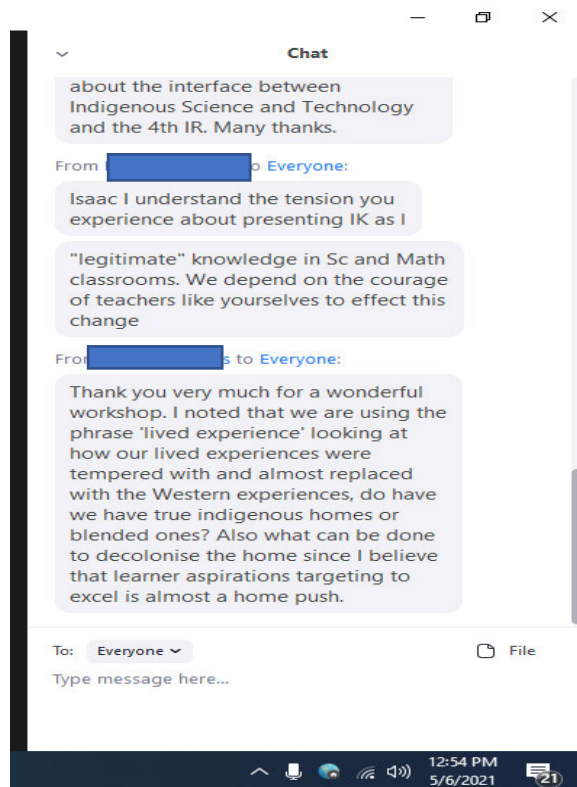
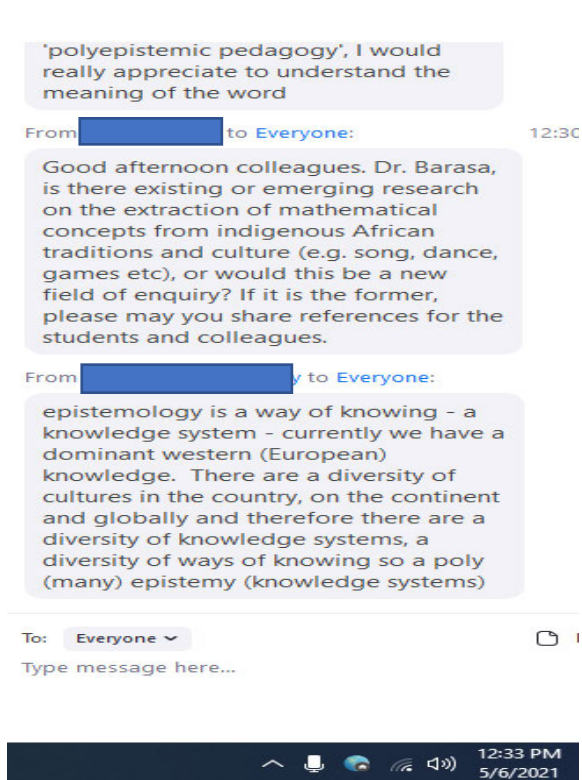
### **Affirmation of Indigenous Knowledge**

While the CIKS recognises the need for external validation of IKS through the interface with other knowledge systems, it puts emphasis on the affirmation of the long experiences of IK holders, practitioners, and local communities in the use of IK-based social practices.

### **The place-based nature of Indigenous Knowledge**

Including its spiritual nature, brings a new dimension of science and research as embedded in IK social practices. This acknowledges the role of IK-holders and practitioners as knowledge producers on their merit ((DSI-NRF CIKS, 2021).

Teachers were able to share their reflections and experiences from the workshop. These are captured below.



### *Reflections of teachers on DSI-NRF CISK workshop*

#### **c. International Year of Basic Sciences for Sustainable Development (IYBSSD) Roundtable - 25/08/2022**

As a part of their continuous professional development, I invited teachers (with IK holders) to attend the IYBSSD Roundtable discussion held on 25/08/2022. Teachers had the agency to attend this event as a part of continuing their PD processes. This also contributed to my understanding and PD related to my study. The discussion was based on interdisciplinarity between basic sciences and the social sciences and Humanities in advancing the Sustainable Development Goals (SDGs). The keynote address was given by Prof. Jonathan Jansen, President of the Academy of Science of South Africa (ASSAf).

Teachers were made aware that the IYBSSD, celebrated in 2022, recognizes that basic sciences are vital to attain sustainable development and improve the quality of life for people all over the world. The Year is being organized by UNESCO, in collaboration with its global partners, from July 2022 to July 2023. I attached my attendance certificate which all participants obtained together with PD points.

## CPD CERTIFICATE



This is to acknowledge that

**Sebastian Sanjigadu**

has attended the following CPD:

**International Year of Basic Sciences for Sustainable  
Development SA Launch & Roundtable**

On the following Date/s: 25 August 2022

And by doing so has qualified for **0.2** CPD credits  
For Continual Professional Development in Category 1

(Validation Number: **2022-0738-002360**)

  
Prof Himla Soodyall  
Executive Officer (ASSAf)

Date: 1 September 2022

**SACNASP**  
South African Council for Natural Scientific Professions

*Certificate of attendance to the (IYBSSD) Roundtable - 25/08/2022*

## Appendix E: Teacher Reflections

(NB. Only teachers who agreed for these to be included are presented here)

### Gift

**20/04/2021**- Most of the textbooks and teaching materials that are used in schools still perpetuate the colonial ideas and belief systems. This can be seen on the Eurocentric examples that are on these textbooks and teaching materials; and also, from the names and origin of the knowledge producer. There are some learners who do well in mathematics but fail to understand how maths concepts work in everyday lives. This may mainly be due to the fact that the examples used in textbooks somehow disconnect them from their lived experience.

**25/04/2021** - I consulted my grandmother –the only indigenous knowledge holder in my family, for some examples that uses the concept of fractions that one can use in teaching this concept for understanding. Furthermore, I consulted some research papers to find out if, 1. it is possible to embed indigenous knowledge and games with Life Sciences; and 2. if there are any studies that have been conducted to assess the practicality and these ideas. Both these attempts were successful.

**07/05/2021** - The strengths of my presentation were availability of indigenous games and knowledge that can be used instead of the Eurocentric examples that are used on the textbooks and teaching material. The sad reality however is that many of our learners may happen not to be familiar with these indigenous games and knowledges, making this a futile exercise as they cannot resonate with these games and knowledges. The plan completely changed me as a teacher. It made me more of a critical thinker than just a traditional science teacher. The plan started to make me question my thoughts behind the different types of teaching methods and approaches that I usually employ in my lessons.

**08/05/2021**- To address these imbalances – the subjugation of African knowledge producers and indigenous knowledge systems, my work looked at how the teaching and learning of the concept of respiration can be infused with indigenous knowledges and games. The idea being to use examples that our learners can resonate with from their everyday lives and experiences. Moreover, the idea was also to show that our indigenous knowledge systems and local knowledge producers are as good and effective as those from Europe. Thus, putting a stop to epistemic violence – the silencing or ignoring of knowledge and beliefs produced by the others – usually non-Western – by Western knowledge producers. My work seeks to critique and transform society to be more equal and fairer so that no group is understood to be dominant than others. This is at par with the critical paradigm which does not only study power imbalances, but also seeks to change and address them.

## **Dwayne**

- **15/04/2021**- Using indigenous game was a way of showing learners that mathematics stems from our elders, They have been playing games like 'IN' (played with numbered shapes) and 'Mlaba-laba' (played with tokens and angels, which is compared to cattle herding by indigenous communities) such information was shared by elders in the community. thus we turn to forget that they did have basic knowledge of mathematics which was used for living. Mosimege (2017) supports that most indigenous people have knowledge of mathematical concepts that are used regularly in their work, however they have no idea that those concepts are mathematical terms. Therefore, this brings a call to invite learners' parents and grandparents in our classrooms when we teach because this notion of integrating indigenous knowledge to the curriculum involve all people.

**20/04/2021**- Moreover, surely the activity made me think differently and critically and the way of thinking now has really changed. For, instance I never thought before that when I am teaching I should include indigenous knowledge in order to spread the notion of our basic knowledge which is indigenous knowledge. Therefore, from now onwards it is very important to teach building up on the indigenous knowledge in order to cater for sustainable education and to achieve SDGs.

## **Lee**

**06/04/2021** - To allow learners to gain knowledge about different methods of preventing malaria which include both Western and indigenous methods. By including the indigenous methods, I wanted to decolonise the textbook that was bias in only teaching about the Western means of preventing and managing malaria. It was important that I make the unit work to be relevant as much as possible to the learners in my class. The plan was to make use of the knowledge from an indigenous knowledge holder who have leaved in a country identified as high-risk area for the disease. After finding out from the IK holder about the mafura tree in managing malaria in Mozambique I decided to incorporate that knowledge into the lesson plan.

**14/04/2021** - It was important to make sure that learners know the tree that was to be discussed as they might be familiar with the tree but fail to recognise it name. So, to address this I had decided to first play a clip about the tree and once the learners notice the tree, I allowed them to discuss the tree in groups as to for them to share what they know. I then made sure that the learners are aware of the impact of malaria in sustainable development and how this can be controlled through making use of this indigenous plant. The strengths were that learners had gain interest in the topic and had so much to say during the discussions. The section that I have selected was able to clearly display the colonised unit of work and the newly decolonised section had made it easy to identify Sustainable Development Goals and how they can be addressed.

## **Precious**

**8th April 2021:** My goal is to create a lesson plan that successfully uses indigenous knowledge as a vehicle to teach a mathematical concept. This lesson should also promote and raise awareness of a few Sustainable Development Goals. After much deliberation and perusal of a 6th grade mathematics textbook, I have chosen to do geometric patterns linked with traditional Zulu beadwork. I really struggled in choosing a topic as I found it difficult to relate concepts to indigenous knowledge. I soon realized that I had been going about it the wrong way, I had to first settle on an indigenous knowledge concept and then relate it to a mathematical one. I found it relatively easy to relate SDGs to Zulu beadwork as I believe all practices can be done sustainably.

**15th April 2021:** At this point in the assignment, I have conducted internet research and interviewed two people to get more information about traditional Zulu beadwork. I interviewed a teacher at a Special School about her personal knowledge and experience with beadwork. She was very forthcoming as she told me about learning from her mother and grandmother. I also interviewed a local artisan who makes and sells Zulu beadwork. He showed me his work and together we discussed the possibility of using it in a classroom setting. From all the information I gathered as well as working with CAPS, I was able to put together a lesson plan about geometric patterns which incorporated traditional Zulu beadwork.

**22nd April 2021:** Upon further working with my lesson, I think its strength lies in the use of cooperative learning throughout the lesson. One of its weaknesses, is that Zulu beadwork mainly includes triangles. It would offer more variety and conceptual understanding if more shapes were used in the beadwork. In future, I would include patterns that I design digitally which incorporates more shapes. These digitally formed patterns would still be in the form of Zulu beadwork. This assignment has made me think more critically. At the beginning I did not see the importance of decolonising the mathematics curriculum specifically because the concepts are universal. However, now I see and feel the importance of decolonising the mathematics curriculum. It will benefit our students greatly. I am now enthusiastically dedicated to raising awareness and promoting the 17 Sustainable Development Goals in my lessons. This is an important endeavour that all teachers and citizens should undertake.

## **Will**

### **Reflective Journal**

**20/04/2021:** At the outset, this assignment requires a vast amount of information to be obtained in order to achieve the desired outcome. My goal is to construct a concise lesson, which will incorporate Indigenous Knowledge (IK) and Sustainable Development Goals (SDGs) in aid of educating learners through the Life Sciences curriculum, about the value and importance of both these sources of information. This task is exciting to work with and will also allow me to add to my current knowledge systems that I have used through my lesson planning.

**22/04/2021:** In order to achieve the goal mentioned in my earlier entry, I had to research various sources of information, as well as find an IK holder to engage with. These strategies will allow me to understand and gain insight into the context in which I may apply the knowledge I receive into the planning of the lesson. In this assignment, I am working with Cat and therefore, together, our knowledge reserves will assist us in preparing a wholesome lesson that enables knowledge of IK and SDGs to be included and passed onto learners in the classroom environment.

**23/04/2021:** Our assignment required a good amount of time in order for us to be completed by the due date, thus Cat and I developed a time schedule in which we would allocate due dates by which each aspect of the assignment will be completed. In terms of strengths and weaknesses, time allocation seemed to be a weakness as at the outset of the task, we were uncertain on aspects of the assignment and thus this delayed our process of writing in terms of Part A. However, a strength that served us through the late start, is that we are now more confident and aware of what is required in the task. This therefore provided us with more time to prepare a well written Part A as compared to one that would have been less developed if we had written it prior to our full understanding of the technicalities within the writing. I met with an IK holder today, who was a 60-year-old, Zulu male. The experience with him, in engaging with IK was successful as I gained valuable knowledge that I was able to elicit through the questions I asked him.

**26/04/2021:** Cat and I have successfully completed the first aspect of the assignment which is a sense of relief for us. In terms of the above weakness mentioned, I believe that in future, to overcome this, we can plan ahead with questioning the task at the outset when it is given to us. This will ensure better time management and a more efficient progress rate. We have planned to complete the task to its full extent by the 29<sup>th</sup> of April.

**Overall Reflection - 01/05/2021:** In terms of critical thinking, despite hearing so much about critical thinking all these years, I realized that I still could not give a concrete definition of it, and I certainly could not explain how to do it. It seemed like something that my teachers just expected us to pick up during our studies. However, through working with the assignment, I researched information on critical thinking skills, as well as reviewed lecture content based on the use of Critical Discourse Analysis that was done in the module and I found that my critical thinking skills had changed in many ways. I found myself always asking basic questions when I reached a dead end, and this helped me to centre

myself and understand the solution I intended to achieve. I have also learnt that it is easy to get lost in vast amounts of information through assumptions and therefore it was important to question the assumptions I made as well as to investigate them further to reassure the knowledge that surrounded them. In addition, I learnt that when you are trying to solve a problem, it is always helpful to look at other work that has been done in the same area. There is no reason to start solving a problem from scratch when someone has already laid the groundwork. But it is also important, however, to evaluate this information critically, or else you can easily reach the wrong conclusion. Furthermore, the assignment made me aware that I also should not get lost within research and that I should also incorporate the knowledge I possess. It was imperative that I recognised that thinking for myself was essential to answering tough questions. I found this to be true when writing Part A – it's so easy to get lost in other people's work that I forget to have my own thoughts. I also learnt that we do not always think critically all if the time. Critical thinking is a tool that should be deployed when you need to make important decisions or solve difficult problems. Thus, through this assignment, my critical thinking skills, and my awareness of the value of critical thinking has become more apparent.

## **Cat**

**04/04/2021** - The goal of this was to incorporate indigenous knowledge to address Sustainable development within a chosen topic in science. The choice of working with a partner, Dwayne, has allowed me to see different perspectives and views.

**12/04/2021** - In order to achieve the goals of this task, extensive research had to be done to have a better understanding of the topic, to understand the indigenous knowledge and its impacts as well as through communication with an indigenous knowledge holder. Through all the previous mentioned we were able to incorporate this into our lesson on "Human Impact on the Environment: Water availability and water quality". Furthermore, we allocated dates and times by when certain aspects of the assignment needed to be completed, however, we had a challenging start as we were uncertain about aspects in part A which caused a delay, however, this time was useful as it enabled us to build a better understanding through communication and research. We had initially planned to complete the assignment by the 29<sup>th</sup>, with the extension to the due date we are able to review work.

**16/04/2021** - Meeting with an indigenous holder had definitely added an interesting aspect, it allowed us to link it to our elder's reality and broaden our views. Our indigenous holder is a 60-year-old Zulu male who has shared his knowledge with us, through this invaluable experience, we were able to not only have our questions answered but gained a lesson on how the inclusion of this knowledge can make a difference in our learners' education and contribute to sustainable development.

**22/04/2021** - Through the participation of this task, it has made me more aware of my teaching and the different indigenous knowledge that can be used, it has taught me to give credit to where it is due and not just based on western knowledge but our own countries achievements. It has also shown me how we as teachers can contribute to the progress of sustainable development goals by creating awareness amongst our students, through our teachings. It has enabled me to think more critically, it helped me to understand and challenge my own biasness. It exposed me other people's explanations and thought processes as well as to new content and new initiators.

### **Thobisa**

**04/04/2021** - In line with grade 4 mathematics curriculum, the curriculum expects specific skills that a learner should develop as sustainable development is also taught. At first, it was difficult to find ways and do planning which would achieve both curriculum (syllabus) and sustainable development. However, the analysis of the CAPS documents especially on the specific aims of the curriculum made it easier as it does promote the ideas of indigenous knowledge. Moreover, the textbook used was in-line with CAPS specific aims to Africanize the curriculum.

**06/04/2021** - Thus, I consulted one of my community elders who does beadwork and sells it. People from the community also hire beadwork from her when there are traditional events using cash. As she explains her skills of developing different beadwork, I identified different mathematical concepts and skills that could be incorporated in teaching grade 4 Geometric patterns. Her explanations made it easier for me to include practical and African examples that could be used in grade 4 geometric patterns and was a bit easier to develop power point slides. I did a lesson plan before I consulted indigenous knowledge holder. I then, re-done my lesson plan as more indigenous ideas were left out which could have been used. Should I be given similar task in future, I will start of by analysis of different textbooks and do consultations with different indigenous knowledge holders before doing I do lesson plans and presentation plans.

**13/04/2021** - One of the weaknesses is that, indigenous knowledge holder that was consulted represent only particular context in Africa and only one cultural group (Zulu). More ideas from different context outside Msinga Rural, KZN province or South Africa could have strengthen the points and more examples that represent Africa. Thus, broad research on the similar concept could strengthen the planning. This activity has extended my view and thinking about mathematics curriculum as I perceived the view that formal mathematics originates in Western countries. However, even in Africa mathematical ideas were applied practically in terms of indigenous games, artwork, beadwork etc. Only that, Africans never recorded their ideas and skills in publications and these ideas were colonised and published by people from Western countries and mathematics was only then viewed as originated outside Africa.

## **Sbu**

**04/04/2021** - For this project I was blessed to work with a 55-year-old grandmother, she is part of school governing body at my school. She resides a little bit far from the school. I approached her to request her to teach my learners about fertilizer specifically organic or traditional fertilizer. I explained to her that I want her to show my learners how she makes traditional fertilisers for her garden and indicated that learners will be working with her following her lead and instructions. She was very delighted to participate in our excursion lesson, she maintained that learners would see that what they learn at school is what they practice at home. She was complaining that as agricultural teachers when teaching we do not involve them much.

## **Essy**

**03/04/2021** - In part A, I have talked about surface area and volume of 3D shapes. The goals of the lesson were to make learners able to use appropriate formulae to calculate surface area, volume and capacity of 3D shapes and solve problems involving area, volume and capacity of any 3D shapes. I have planned to achieve these goals by doing practical activity together with learners during lesson presentation. Explain to learners' step by step on how to solve word problems involving area, capacity and volume by explaining to them that they need to understand the problem and be able to identify what is given (data) and what is needed (unknown). Also give learners opportunity to solve problems in groups and do it practically and as a teacher facilitate to guide their thought.

**10/04/2021** - I have learned to develop a lesson plan by making sure that I engage IKS and SDGs in the lesson. Learner's activity allows them to solve activities that link to IKS and enables them to go and find information about the lesson to their elders, people familiar with indigenous knowledge system and link it to the topic. Strength of the plan is that the outcomes of the lesson achieved because I have observed that learners mastered the concept. In the activities they did almost 80% of the learners got total in their activity and there is no learner that got less than 40%. Weaknesses of the lesson is that we didn't have much time to do practical and play indigenous game because learners did two practical activities due to time limit. In future, I will tell learners that the next lesson is about what so that they can bring their own materials to prepare for doing practical activity. I will also highlight kinds of materials that we will need. This can help to save time because in this lesson, groups were sharing some of the materials like scissor, ruler etc.

**20/04/2021** - This activity made me think more critically because I was thinking to ask maths teachers in my school and other schools in same circuit to work together with me and plan for maths day. Learners will compete. They will play indigenous games with other learners from different schools. Competition will be learners from grade 7 to grade 9. Each grade will complete with the same grade from other school. Learners will explain how to play it, how to see that a group or person is losing a points or gaining points. They will also explain how is related to mathematics. By doing this, I will be trying to attract learners to love mathematics concepts.

## **Nicki**

**04/04/2021**

This decolonial task to leverage indigenous knowledge to address the Sustainable Development goals seemed daunting as this unfamiliar territory in teaching, this is not

something we think about generally when we teach, this has not only expanded my knowledge but allowed me to explore the different ways of how this can be used to decolonise the curriculum whilst at the same time address sustainable development.

## Appendix F: Ethical Clearance from the University of KwaZulu-Natal



04 February 2021

Mr Sebastian Sanjigadu (213518917)  
School of Education  
Edgewood Campus

Dear Mr Sanjigadu,

Protocol reference number: HSSREC/00002271/2021

Project title: Addressing Sustainable Development Goals by leveraging indigenous knowledge: Experiences of Science and Mathematics teachers

Degree: PhD

### Approval Notification – Expedited Application

This letter serves to notify you that your application received on 17 December 2020 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted FULL APPROVAL.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 04 February 2022.

To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,



Professor Dipane Hlalele (Chair)

/dd

### Humanities and Social Sciences Research Ethics Committee

Postal Address: Private Bag X54001, Durban, 4000, South Africa

Telephone: +27 (0)31 260 8350/4557/3587 Email: hssrec@ukzn.ac.za Website: <http://research.ukzn.ac.za/Research-Ethics>

Founding Campuses: ■ Edgewood ■ Howard College ■ Medical School ■ Pietermaritzburg ■ Westville

INSPIRING GREATNESS

## Appendix G: Informed consent letter- Teachers



Science and Technology Cluster,  
School of Education,  
College of Humanities,  
University of KwaZulu-Natal,  
Edgewood Campus, KwaZulu-Natal  
Date

Dear Teacher

### **INFORMED CONSENT LETTER for Honours science and mathematics students (Teachers)**

My name is Sebastian Sanjigadu I am a **Doctor of Philosophy (Ph.D.)** student from the Science and Technology Cluster, School of Education, College of Humanities, University of KwaZulu-Natal. I am conducting research titled **Addressing Sustainable Development Goals by leveraging indigenous knowledge: Experiences of Science and Mathematics teachers.**

Several studies suggest that if education is to “play a transformative role in relation to Sustainable Development then education policy needs to be fundamentally reoriented and address processes of economic, cultural and political transformation in the interests of social and environmental justice (Tikly, 2019, p. 223).” One of the ways that this reorientation can exist is by using indigenous knowledge within the school science and mathematics curriculum through a decolonial approach. It is therefore essential to explore how sustainable development goals can be addressed by leveraging indigenous knowledge. The exploration of these as a part of teacher professional development at Higher education institutions is important.

In view of the foregoing, I intend to explore and raise teacher awareness of colonisation and SD in the science and mathematics curriculum, and to stimulate their commitment and action to work towards decolonising the curriculum. Teachers will be encouraged to focus on Education for Sustainable Development to achieve this.

**The objectives of this study are:**

To explore:

1. How science and mathematics teachers address sustainable development goals by leveraging indigenous knowledge.
2. The pedagogical experiences of science and mathematics teachers who have engaged in professional development activities in planning to address the sustainable development goals by leveraging indigenous knowledge in the school curriculum.
  - (a) The types of strategies science and mathematics teachers who have engaged in professional development activities use to plan to enact the school curriculum when leveraging indigenous knowledge to address the sustainable development goals.
  - (b) Why science and mathematics teachers who have engaged in professional development activities use the strategies they use.
3. The experiences which constrain or enable teachers who seek to address the sustainable development goals by leveraging indigenous knowledge.
  - (a) The factors that obstruct or enable when leveraging indigenous knowledge to address the sustainable development goals in the school curriculum.
  - (b) How science and mathematics teachers respond to these factors.

You are invited to please participate in the study because you are a student who is studying the science and mathematics Curriculum Development Honour Module. To gather the information, I am interested in requesting you to participate in this project by reflecting critically (on which you will work with other students) to decolonise a unit of work from the science or mathematics CAPS curriculum using indigenous knowledge. Your lesson will also need to address the Sustainable Development Goals. As a part of this task, you will need to recruit an indigenous knowledge holder who could be a 'sangoma', 'inyanga', 'elder', community leader, or anyone who may have indigenous knowledge. Once you have worked within your group to decolonise the unit of work you choose, this will need to be presented to your peers which I will observe. This will be established as part of the module tasks, for 12 weeks.

I will also ask you some questions during two group interviews, each of 25-30 minutes duration. In addition, I will also ask you to keep a reflective diary and will look at your portfolio, in which you would have recorded your views and experiences related to the decolonised task. I will also take supplementary field notes from my observations and conversations related to your professional development.

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number HSSREC/00002271/2021).

Please note that:

- Your participation is voluntary. If you do not participate you **will not be penalized** in any way. No marks will be deducted from your project if you decline to participate.
- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member's opinion.
- Two focus group interviews will last for about 25-30 minutes each and may be split depending on your preference.
- Any information given by you cannot be used against you, and the collected data will be used for this research only.
- Data will be in the form of interview transcripts, completed diary entries, and completed portfolios, and will be stored in secure storage and destroyed by shredding after 5 years. Digitally recorded data will be deleted after five years.
- You have a choice to participate, not participate, or stop participating in the research. You will not be penalized for taking such an action.
- Your involvement is purely for academic purposes only, and there are **no financial** benefits involved. However, it is expected that you will gain insight into curriculum decolonisation, Education for sustainable development, and integration of indigenous knowledge into the curriculum.

Thank you

Yours faithfully

S. Sanjigadu

.....

My contact details are as follows:

Email: 213518917@stu.ukzn.ac.za

Cell phone: 074 500 8509

My supervisor is Professor Ronicka Mudaly She is a Lecturer at the School of Education, College of Humanities, Edgewood Campus, University of KwaZulu-Natal

My supervisor's contact details are:

Email: Mudalyr@ukzn.ac.za

Phone number: 031 260 3643

You may also contact the Research Office at:

**University of KwaZulu-Natal**

**Humanities and Social Sciences Research Ethics**

**Govan Mbeki Centre**

**Tel +27312604557**

**Email: [HSSREC@ukzn.ac.za](mailto:HSSREC@ukzn.ac.za)**

Thank you for reading this document about this research.

## DECLARATION OF CONSENT

I ..... (Full names of participant) hereby confirm that I have been informed about the study entitled 'Addressing sustainable development goals by leveraging indigenous knowledge: A case of Science and Mathematics teachers.' by Sebastian Sanjigadu. I understand the contents of this document and the nature of the research project, and I consent to participate in the research project.

I understand the purpose and procedures of the study.

I have been allowed to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without negative consequences.

**I voluntarily give permission for the interviews to be video and audio-recorded.**

**I give permission for my reflective diary and student portfolio to be used as a source of data.**

**My identity will not be disclosed and pseudonyms will be used to protect my identity**

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at Email: [213518917@stu.ukzn.ac.za](mailto:213518917@stu.ukzn.ac.za) Cell phone: 074 500 8509

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researcher, then I may contact:

### **HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION**

**Research Office, Westville Campus**

**Govan Mbeki Building**

**Private Bag X 54001**

**Durban**

**4000**

**KwaZulu-Natal, SOUTH AFRICA**

**Email: HSSREC@ukzn.ac.za**

Additional consent, where applicable

- I am willing to be part of the decolonial task, presentation, and interviews. I am also willing to allow recording by the following equipment, and the use of other data:

	Willing	Not willing
Digital video and audio recordings of interviews		
Use of portfolio of evidence		
Use of reflective diary		

.....

**Name of Participant**

.....

**Signature of Participant**

.....

**Date**

## Appendix H: Gatekeepers' Permission Letter



22 December 2020

Sebastian Sanjigadu (SN 213518917)

School of Education

College of Humanities

Edgewood Campus Email: [213518917@stu.ukzn.ac.za](mailto:213518917@stu.ukzn.ac.za) [mudalyr@ukzn.ac.za](mailto:mudalyr@ukzn.ac.za)

Dear Sebastian

### RE: PERMISSION TO CONDUCT RESEARCH

Gatekeeper's permission is hereby granted for you to conduct research at the University of KwaZulu-Natal (UKZN), towards your postgraduate degree, provided Ethical clearance has been obtained. We note the title of your research project is:

*"Addressing Sustainable Development Goals by leveraging indigenous knowledge: Experiences of Science and Mathematics teachers."*

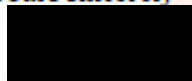
It is noted that you will be constituting your sample by conducting focus group interviews with Teachers (Taking in account the regulations imposed during lockdown ie restrictions on gatherings, travel, social distancing etc. Zoom, Skype or telephone interviews recommended) on the Edgewood Campus.

Please ensure that the following appears on your notice/questionnaire:

- Ethical clearance number;
- Research title and details of the research, the researcher and the supervisor;
- Consent form is attached to the notice/questionnaire and to be signed by user before he/she fills in questionnaire;
- gatekeepers approval by the Registrar.

You are not authorized to contact staff and students using 'Microsoft Outlook' address book. Identity numbers and email addresses of individuals are not a matter of public record and are protected according to Section 14 of the South African Constitution, as well as the Protection of Public Information Act. For the release of such information over to yourself for research purposes, the University of KwaZulu-Natal will need express consent from the relevant data subjects. Data collected must be treated with due confidentiality and anonymity.

Yours sincerely



**DR KE CLELAND: REGISTRAR**

### Office of the Registrar

Postal Address: Private Bag X54001, Durban, 4000, South Africa

Telephone: +27 (0)31 260 7971 Email: [registrar@ukzn.ac.za](mailto:registrar@ukzn.ac.za) Website: [www.ukzn.ac.za](http://www.ukzn.ac.za)

Founding Campuses: ■ Edgewood ■ Howard College ■ Medical School ■ Pietermaritzburg ■ Westville

**INSPIRING GREATNESS**

# Addressing SDGs

*by Sebastian Sanjigadu*

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