

**Scaffolding teachers' professional development
for the infusion of indigenous knowledge transfer
in the Technology classroom**

Benjamin Seleke



orcid.org/0000-0002-9191-5653

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Doctor of Philosophy in *Curriculum Studies*
at the North-West University

Promoter: Prof. J.J.J. de Beer

Graduation ceremony: July 2021

Student number: 18047335

DEDICATION

**This thesis is dedicated to my late parents
Olihile David Seleke and Morwesi Elizabeth Seleke
You have left foot prints in my heart to see value in education.
Thank you very much.**

ACKNOWLEDGEMENTS

I thank God Almighty, Father of our Lord Jesus Christ, for giving me the courage to pursue my post-graduate studies.

My sincere gratitude goes to my study leader Prof. J.J.J. De Beer for his guidance, support and encouragement.

To my beautiful wife Gaobusetse Maria Seleke, my sons Tshepang, Tumelo and Neo, and my sisters Tlwaelo, Mmotseng, Babotseng and Setshameko (Tannie), thank you for your support and understanding during the course of my studies. You all stood by me and that meant so much.

To the participants of my study, thank you for sharing your knowledge, experiences and expertise.

To the entire Self-Directed Learning IK-community of practice (CoP), well done you did it.

To the NWU, *National Research Foundation* and the *Fuchs Foundation* for the financial support in ensuring the success of my study.

ABSTRACT

In his 2017 publication, Mishack Gumbo, a leading authority on the pedagogical integration and use of Indigenous Knowledge for Technology Education in Sub-Sahara Africa, called for researchers to explore the integration and use of indigenous technologies for the professional development of Technology teachers in South Africa, and furthermore to investigate the attitudes of Technology teachers towards indigenous technologies. My research is a direct response to Gumbo's call for researchers to explore the integration and use of indigenous technologies for the professional development of Technology teachers in South Africa, and furthermore to investigate the attitudes of Technology teachers towards indigenous technologies. Currently, there are not design principles that would serve as a guide for Technology teachers to infuse Indigenous Knowledge in their classroom.

In my literature study, Socio-Cultural Constructivism is discussed as the higher order theoretical construct of my case study. Furthermore, a distinction is made between various lower order constructs, which together, constitute the conceptual framework of my research. These include: Cultural Responsive Theory, the continuous professional development of Technology teachers, the reformation and decolonisation of the school curriculum, the origins, core content areas and objectives of Technology Education in South Africa, self-directed learning, and problem-based learning. Next, Indigenous Knowledge Systems and Indigenous Technologies were explored, followed by a discussion on the andragogical and pedagogical infusion of Indigenous Knowledge into Senior Phase Technology Education. Indigenous Knowledge various barriers and challenges were identified that still restrict the effective infusion of Indigenous Knowledge into Technology Education, and accordingly, possible solutions were explored from the literature, aimed to overcome these barriers and challenges.

I followed a qualitative case study research design, and made use of a design-based research approach, consisting of three intervention cycles. Participants in all three the intervention cycles were Technology teachers. The first intervention cycle consisted of five (5) participants, the 2nd intervention cycle consisted of eight (8) participants while the 3rd intervention cycle consisted of five (5) participants. I progressively delivered a three-day long short-learning programme to three groups of senior phase Technology teachers, that assisted the participants to integrate and tap into their culturally accumulated Indigenous Knowledge and skills, and use this knowledge and skills together with their design process skills in Technology Education, in order to collaboratively solve community-based problems by designing and constructing indigenous technological artefacts for given scenarios, while simultaneously promoting both transfer of

knowledge and skills in the classroom, and encouraging self-directed learning. Central to this study was to distil design principles that would inform future teacher professional development programmes on the infusion of Indigenous Knowledge in technology classrooms in the manner that will promote both transfer of knowledge in the classroom, and self-directed learning. Also, after each of the interventions, changes were made to the short learning programme, in true design-based research fashion. During the progressive intervention cycles, I used various qualitative data collection methods to generate an integrated dataset, comprising of teachers' self-reflection sheets, their constructed indigenous technological artefacts, mind-maps drawn by participants, as well as data collected by means of a focus group interview, participants' portfolios, as well as participants' responses to a qualitative questionnaire that was administered to them at the end of their participation in the short-learning programme.

I furthermore made use of third generation Cultural Historical Activity Theory (CHAT) as a research lens to explore the challenges experienced by senior phase Technology teachers when applying Indigenous Knowledge and skills in their classrooms. Meticulous qualitative data analysis revealed Technology teachers benefited from the Short Learning Programme (SLP), and also indicated the need for continuous in-service teacher professional development, coupled with structured support. I applied the findings obtained from my literature review, together with the findings derived from my qualitative data analysis of the data collected during the three intervention cycles, to distil design principles for the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education, that will promote both transfer of knowledge in the classroom, and self-directed learning.

Keywords: **Indigenous Knowledge; Indigenous Technologies; Technology Education; Design Principles; Cooperative Learning; Continuous Teacher Professional Development; Problem Based Learning; Self-Directed Learning; Short Learning Programme (SLP).**

SOLEMN DECLARATION OF AUTHORSHIP

I, BENJAMIN SELEKE, hereby solemnly declare that this thesis entitled:

**“Scaffolding teachers' professional development for the infusion of
Indigenous Knowledge transfer in the Technology classroom”**

Submitted for the degree Doctor of Philosophy in Curriculum Studies, at the Potchefstroom Campus of the North-West University, is my own independent work, and that I have not previously submitted the same work for a qualification at or in any other university. I furthermore declare that no work of other scholars has been used without the means of proper citation and that all the sources used or quoted have been indicated and acknowledged by means of complete references. Prior to the completion of this thesis report, I had the privilege to co-author and publish one book chapter and two conference papers in conference proceedings, in which I already reported some of the findings of this study. These publications are:

- Seleke, B., Els, C.J. & De Beer, J. (2019). Utilising Indigenous Knowledge in Higher Education for the professional development of culturally responsive Technology teachers. In J. Pool & M. Fernandes-Martins (Eds). A Scholarly Approach to Student Success in Higher Education. Potchefstroom: Ivyline Academic Publishers.(ISBN: 978-1-990924-01-9)
- Seleke, B., Speight Vaughn, M. & De Beer, J. (2018). Senior Phase Technology teachers' professional development and implementation needs: a case study. *Proceedings of the 9th Annual UNISA ISTE Conference on Mathematics, Science and Technology Education, 22 to 25 October 2018, Kruger National Park.*
- Seleke, B., Havenga, M. & De Beer, J. (2019). The Enhancement of self-directed learning through the engagement in problem-based learning activities during a professional development programme on Indigenous Knowledge for Technology teachers. *Proceedings of the 8th International ISES Teaching and Education Conference, 17 September 2019, Vienna, Austria.*

Although some sections of this research report are therefore aligned with these publications, I gave due credit where applicable. I hereby cede copyright of my PhD Thesis to the *North West University*. BENJAMIN SELEKE

Date: **23 March 2021**

Signed:  _____

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ETHICAL CLEARANCE CERTIFICATE



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YUNIBESITHI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Fakulteit Opvoedkunde / Faculty Education
Privaatsak / Private Bag X6001, Potchefstroom
Suid-Afrika / South Africa 2520
T: 018 299 4656
F: 086 661 8589
<http://www.nwu.ac.za>

6 April 2020

To Whom It May Concern

I hereby confirm that ethics application, as stated below, was approved by the critical readers and will be minuted at the EduREC meeting of 30 April 2020.

Ethics number: NWU-00791-18-A2

Project head: Prof JJJ de Beer

Project team: B Seleke (PhD student – 18047335)

Title: Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom

Extended period granted: 6 April 2020 – 6 April 2021

Clearance given for only one year. Extension can be requested after a year.

Risk level: Low

Should you have further enquiries in this regard, you are welcome to contact Prof Jako Olivier at 018 285 2078 or by email at Jako.Olivier@nwu.ac.za or Ms Erna Greyling at 018 299 4656 or by email at Erna.Greyling@nwu.ac.za.

Yours sincerely

Prof J Olivier
Chair Edu-REC

CERTIFICATE OF PROOFREADING AND LANGUAGE EDITING



Faculty of Education
Cape Peninsula University of Technology
Jan van Riebeeck Road
Wellington
7654
13/3/2021

To whom it may concern,

This letter serves to inform you of the fact that I undertook standard editing procedures for the thesis entitled:
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The editing process included the following:

- Checking spelling, grammar and punctuation
- Checking syntax and morphology
- Correction of concord errors and the appropriateness of verb tenses
- Transitional phrasing
- Continuity of thoughts
- Supporting statements and argumentation

Thank you for your consideration in this matter.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Livingston', with a stylized flourish at the end.

Dr Candice Livingston
Research co-ordinator and Senior Lecturer (English)
Faculty of Education
Cape Peninsula University of Technology
livingstonc@cput.ac.za

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Chapter 1

Background and Orientation

Bana ba kgwale baitsanye ka molodi

(The children of the partridge know each other by their chirp)

Chapter 1

Background and Orientation

1.1. Introduction and Problem Statement

South Africa has a rich diversity of people from different traditions, languages, and cultures (Le Roux, 2000). During the past 25 years, the country has undergone a dynamic educational transformation aimed at establishing an inclusive education system, in order to ensure every child's fundamental human right to basic education. This right is enshrined in Section 29 (1) of our Constitution (Republic of South Africa, 1996). Most inclusive classrooms include learners from diverse cultural, language, and socio-economic backgrounds, who have diverse educational abilities and needs. Inclusive education shifts the focus from learners having to "fit into" the system, to schools and teachers transforming themselves in order to accommodate and address the educational needs of a diversity of learners by means of varied learning experiences (Landsberg, Krüger, & Swart, 2019).

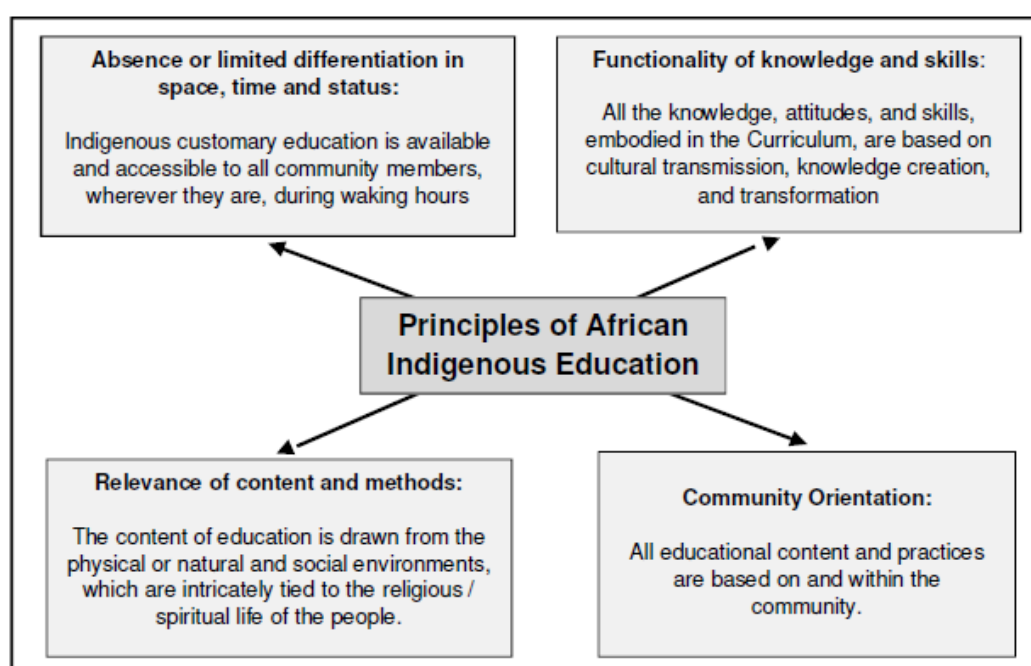


Figure 1.1: Guiding Principles of African Indigenous Education, identified by Kisanji (1999), on which the success of inclusive education systems essentially depends

Such a stance also needs to consider the knowledge that learners bring to the classroom, and to acknowledge the rich Indigenous Knowledge systems that South Africa hosts. As I will later

argue in this thesis, Indigenous Knowledge could serve as a vehicle to better contextualize the school Curriculum for culturally diverse learners, and whet their appetites to become lifelong science, technology, engineering and mathematics (STEM) learners. An interesting example, that juxtaposes South Africa's rich indigenous knowledge, with its strive to be a world leader in terms of science and technology, is illustrated in Figure 1.2.



Figure 1.2: A central premise of this thesis, is that the epistemological border-crossing between Indigenous Knowledge and the Technology Curriculum content holds affordances for learning in the Technology classroom. In this figure, the oldest Indigenous Knowledge system in the world, that of the San, is juxtaposed with the cutting-edge science and technology displayed in the radio telescopes of the Square Kilometre Array, in the Carnarvon district in the Northern Cape Province, South Africa. In the photograph, Oupa Jan Pietersen, a San leader, poses in front of the telescope antennas, during a blessing ceremony of the San Council on site. [Acknowledgement: Dr Anton Binneman, the National Research Foundation, and the South African Radio Astronomy Observatory].

Kisanji (1999) highlights the fact that African indigenous education is fundamentally inclusive in nature, and concludes that the success of inclusive education systems essentially depends on the four guiding principles of African indigenous education, summarised in Figure 1.1. As our school Curriculum has been moulded from the values and principles of our Constitution (Republic of South Africa, 1996), it therefore duly recognises inclusive principles such as *Indigenous Knowledge Systems* (Gumbo, 2017). The third aim of the *Curriculum and Assessment Policy Statement for Grades 7-9 Technology* states that:

"Wherever possible, learners should be made aware of different coexisting knowledge systems. They should learn how indigenous cultures have used specific materials and processes to satisfy needs, and become aware of indigenous intellectual property rights"(Department of Basic Education, 2011, pp. 7-8).

Although this Curriculum statement promotes awareness of, and indirectly hints towards the possible integration and use of Indigenous Knowledge and technologies into Technology Education, it is justly criticised by Gumbo (2017) for opening with the phrase *"Where possible..."* which does not actually convey a message of real commitment towards the integration of Indigenous Knowledge in Technology Education. The consequence of the Curriculum Policy's lack of commitment towards the integration and use of Indigenous Knowledge and indigenous technology, is that almost all educational training, workshops and programmes that deliver continuous teacher professional development, are also lacking in the same commitment. Gumbo (2017, p. 155) also points out that the inclusion of the phrases "made aware" and "become aware" in the Curriculum statement, really boils down to no integration of indigenous technologies, while the phrase "have used" furthermore suggests that Indigenous Knowledge is something which is extinct, from a past history. Another problem is that STEM teachers are generally not trained in infusing Indigenous Knowledge in their teaching of the Curriculum and Assessment Policy Statement (CAPS) themes (De Beer & Mentz, 2019; De Beer & Van Wyk, 2019).

Gumbo (2017) highlights various areas within the South African Technology Education landscape that, for the most part, still remains unexplored, and makes a call for researchers to conduct investigations into these crucial knowledge areas that are in dire need of research consideration. Whereas substantial work has been done in terms of infusing Indigenous Knowledge in the Natural-, Physical and Life Sciences school curricula in South Africa (De Beer & Van Wyk, 2019; Mentz & De Beer, 2017; Petersen, Golightly, & Dudu, 2019), relatively little research has been done in terms of Indigenous Knowledge in Technology in South Africa. Scholars like Ankiewicz (2020) started to make significant contributions in this nascent scholarship. However, Higher Education for continuous teacher professional development is one of these areas that still exhibits a void in the existing corpus regarding indigenous knowledge. The attitudes of South African Technology teachers towards indigenous technology is, yet another, knowledge area that still remains uncharted by existing research. This qualitative case study is a direct response to Gumbo's (2017) call for research into these under-explored knowledge areas. As a result, I developed a short learning programme at the North-West University for the continuous professional development of senior phase Technology teachers that provided learning opportunities for participating teachers to integrate and use their culturally accumulated Indigenous Knowledge and skills, together with their design process skills in Technology Education, to collaboratively solve community problems by

designing and constructing indigenous technological artefacts for given scenarios. As part of my short learning programme, presented over a period of three days, I also encouraged participating Technology teachers to openly share their lived experiences pertaining to their integration and use of Indigenous Knowledge and skills to attain professional andragogical development into the core content areas in the senior phase Technology Curriculum.

1.2. Ubuntu as African Philosophy of Life and Education used as the Ontological Looking Glass for this qualitative case study

I used *Ubuntu* as the ontological looking glass (worldview perspective) through which I viewed my qualitative research. *Ubuntu* is an indigenous African philosophy of life and education, the soul of which is encapsulated in the Setswana proverb: “*motho ke motho ka batho ba bangwe*”, i.e. *a human can only be a human through other human beings* (Mbigi & Maree, 2005). *Ubuntu* advocates that: *I am because of the other, my existence is not in isolation from my society*. The wellbeing of the entire society is intertwined in co- existence with its members in such a way that one cannot exist without the other (Mabovula, 2011). *Ubuntu* furthermore holds that we all need each other in order to make sense of the world, we learn best through collaborative efforts to achieve community-based learning outcomes, and that education and culture form an interconnected and interdependent unity. The relevance of *Ubuntu* as a philosophy of education, was mostly undervalued in the past (Mbigi & Maree, 1995; Taylor, 2014b). More recently, *Ubuntu* became widely recognised as the ontological nexus and driving force behind the educational movement towards the decolonisation of Curriculums and the re-visioning of education throughout the African continent (Mbiti, 1969; Obanya, 2018; Takyi-Amoako & Assie-Lumumba, 2018). A growing number of African scholars (e.g. Gumbo, 2015, 2017; Kamwangamalu, 1999; Le Grange, 2012; Louw, 2011; Mentz & De Beer, 2017) share the same vision of regaining the education that Africa lost as a result of its’ colonisation. According to Obanya (2018, pp. 87-90), indigenous African education is based upon the following educational principles:

- (i) Culture as the cornerstone of education.
- (ii) An all-inclusive education system of life-long learning, mapped out according to the developmental stages of life.
- (iii) Articulation of education through informal and diverse routes to learning.
- (iv) Emphasis on gaining life skills based upon the normal and organisational patterns and modes of society and culture.
- (v) Social recognition and a high regard for educators as knowledgeable and skilled members of the community.
- (vi) The use of socially accepted pedagogy, e.g. oral communication, instructing,

demonstrating, encouragement and admonishment, repetition, team/group teaching and collaborative learning, internships and apprenticeships.

1.3 Socio-Cultural Constructivism as Theoretical Framework Underpinning this Study

This section provides a preliminary overview of *Socio-Cultural Constructivism* as the theoretical foundation of my qualitative investigation. A more detailed discussion of the theoretical framework is provided in Chapter 2 of this research report. The theoretical framework of *Socio-Cultural Constructivism* underpinned the design of the short learning programme on the infusion of Indigenous Knowledge into Senior Phase Technology Education Curriculum themes, which was developed and implemented at our Higher Education Institution for the continuous professional development of Technology teachers. I namely wanted to scaffold Technology teachers' learning across the 'zone of proximal development' (Vygotsky, 1978; Vygotsky, 1986). The short learning programme supported teachers in learning how to incorporate Indigenous Knowledge into their teaching, and to scaffold their professional development from 'actual development' 'towards 'potential development' (Vygotsky, 1978).

This qualitative case study is grounded in Socio-Cultural Constructivism as a branch of constructivist theory which underscores that culture and tools play a pivotal role in learning (Vygotsky, 1978). As posited by Vygotsky (1978), the philosophical grounds for constructivism asserts that meaningful learning is a result of a collective effort between the lecturer-researcher and teacher-students, as well as between teachers and their learners, ensuring that knowledge acquisition results from their interaction within their socio-cultural context. Socio-Cultural Constructivism is therefore the ideal theoretical framework for underpinning my qualitative case study, for my intention was to successfully scaffold learning during the presentation of the short learning programme, across Vygotsky's Zone of Proximal Development. Studies by Hausfather (1996) and Wertsch and Sohmer (1995), reported that Vygotsky's socio-historical method for perceptive growth, affords the reinforcement of socio-cultural constructivism within classrooms. Adams (2006) posits that knowledge construction can therefore not be disconnected from the social environment from which it is moulded. Out of Vygotsky's social constructivism, emerged the *Zone of Proximal Development*. The zone of proximal development may be defined as:

"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers"(Vygotsky, 1978, p. 86)

The zone of proximal development embodies a phase in the development of a learner/student where the learner/student is incapable of executing an assignment single-handedly, but can ultimately complete it with the assistance and direction of someone more knowledgeable (Christmas, Kudzai, & Josiah 2013). Buttressing this notion, Hausfather (1996) identified three distinctive characteristics related to the zone of proximal development. Firstly, that the paramount means to apprehend the mind, is to observe how it transforms. Secondly, that the advancement of intellectual functions has its origins in social activity; and thirdly that advanced perceptual functions are facilitated by tools and signs. Drawing from these three distinctive characteristics postulated by Hausfather (1996), the zone of proximal development perspective of Vygotsky (1978) is contextualized for my research. Warford (2011) developed this theory further by coining the term “*Zone of Professional Teacher Development*”, which is relevant to the development of the short learning programmes used in this investigation, as it capacitates teachers with pedagogical skill and content knowledge, in order to effectively infuse Indigenous Knowledge (IK) in their technology classrooms.

According to Warford (2011, p. 253), the “*Zone of Professional Teacher Development*” denotes:

“the distance between what teaching candidates can do on their own without assistance, and a proximal level they might attain through strategically mediated assistance from more capable others”.

In addition, Fania and Ghaemib (2011), add that the “*Zone of Professional Teacher Development*” methodically advances teachers’ understanding, which is persistently re-shaped to house the vigorous nature of the classroom environment. Constructivists hold the view that there is a constant bond between what is to be learned by a learner/student and what a learner/student already knows (Harland, 2003). For this reason, teachers are therefore strategically positioned to construct a conducive atmosphere for meaningful learning that could stimulate positive interdependence through scaffolding and collective learning (Morcom, 2014). Good teaching practices should therefore be designed to reach learners’ zone of proximal development, so that they will be able to draw from the expertise of their teachers, in order to complete learning activities they find challenging to execute (Macy, 2016).

1.4 Conceptual framework underpinning this qualitative case study

I distinguish between Socio-Cultural Constructivism, as a higher-order theoretical construct of my research, and the conceptual framework used in my research, consisting of various lower-order constructs, i.e. teachers’ professional development, Socio-Cultural Constructivism,

cultural responsive teaching theory, decolonization, indigenous knowledge, self-directed learning. My conceptual framework could be compared to what Engestrom (2011) calls 'intermediate theories'. Accordingly, this section provides an overview of the central intermediate theories that guided my study.

1.4.1 Cultural Responsive Teaching Theory

I applied culturally responsive teaching theory as the first construct of the conceptual framework used for my research. According to Szu-Yin and Shernaz (2014), culturally responsive teachers should be able to reflect on their own teaching practices, and should have the knowledge and skills to employ different culturally responsive methodologies, in order to become responsive to the diverse needs of learners in their inclusive classrooms. Culturally responsive teaching also demands from teachers that they re-organize their classrooms in order to become accommodative towards the diverse cultural and linguistic needs of learners, and to align their classroom contexts with the contexts of their communities (Mahlangu & Mafuwane, 2015; Szu-Yin & Shernaz, 2014). As diversity influences the way in which teaching and learning manifest in classrooms (Mahlangu & Mafuwane, 2015), Technology teachers should become aware of the diverse needs and expectations of learners, in order to align their teaching practices so that they become relevant to the diverse contexts of their learners. According to Gay (2002), culturally responsive teachers make use of different pedagogical approaches so that their teaching becomes relevant to their learners' diverse cultural backgrounds, as meaningful learning is attainable when the social and cultural background of student are taken into account (Gwekwerere 2016).

For the purpose of this qualitative case study, I applied Figure 1.3 (i.e. presented on the next page), as a construct of my conceptual research framework, as adapted by Gumbo (2018) from King, Artiles and Kozleski (2009), to the unique context of my case study, in order to develop a Higher Education short learning programme for the continuous professional development of senior phase Technology teachers, which provided andragogical opportunities for participating teachers to integrate and use their culturally accumulated Indigenous Knowledge and skills, together with their design process skills in Technology Education, to collaboratively solve community problems by designing and constructing indigenous technological artefacts for given scenarios.

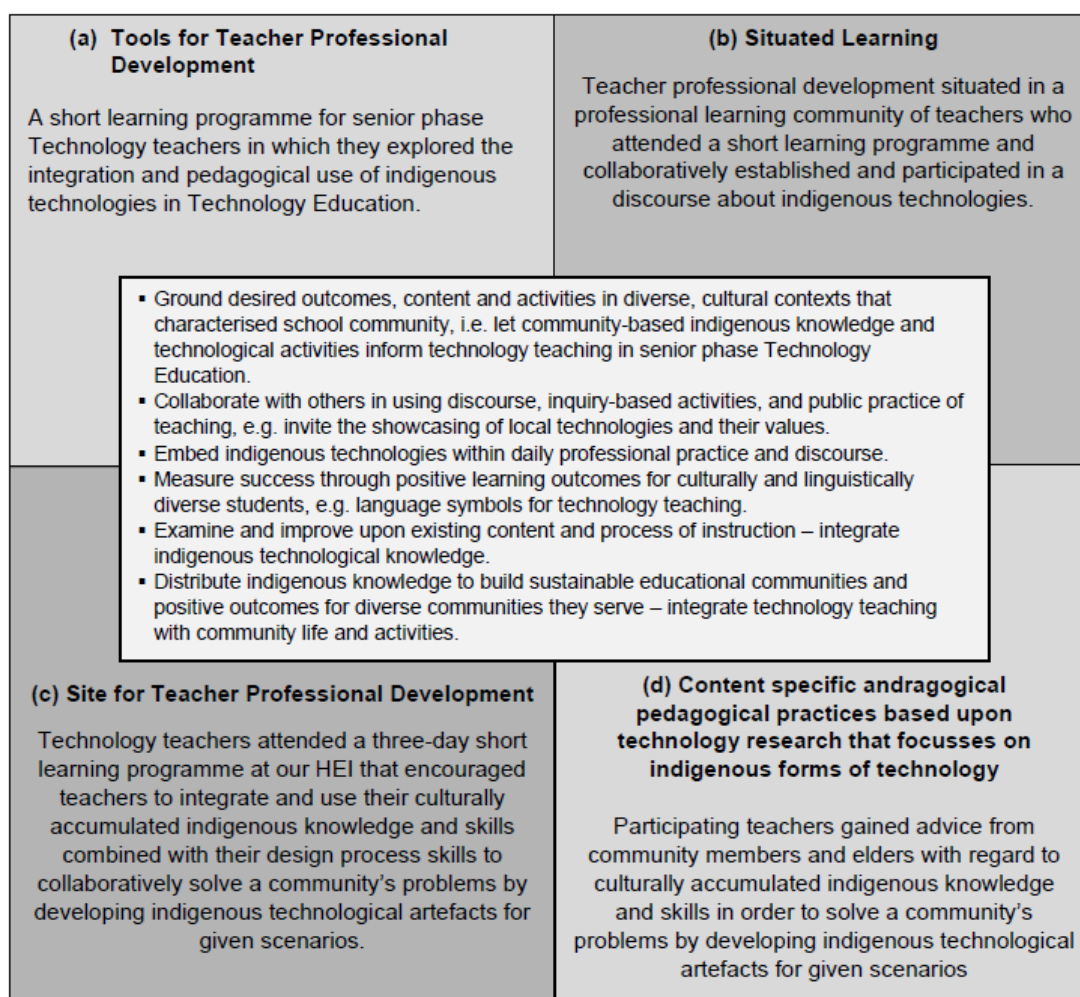


Figure 1.3: Andragogical Development of Culturally Responsive Senior Phase Technology teachers (adapted from Gumbo, 2018)

1.4.2 Teachers' professional development

Teacher Professional Development (TPD) is crucial for the continuous enhancement of teachers, as it in turn, enables them to use their newly gained knowledge and skills to also improve the achievement of learners (Carr, McGee, Jones, McKinley, & Bell, 2000). TPD is further regarded as the path of introducing new content, new teaching and learning strategies and new ways of assessment aimed at achieving pedagogical and Curriculum reform. Many countries across the world have prioritized TPD as part their enhancement of the pedagogical skills of their teaching force (Mokhele & Jita, 2010). Like most countries, the South African Department of Basic Education (DBE) has a policy framework in place in order to ensure that its teachers meet the educational demands of the 21st century. The National Policy Framework for Teacher Education and Development in South Africa (Department of Education, 2006, p. 4), *"is designed to develop a teaching profession ready and able to meet the needs of a democratic South Africa in the 21st century. It brings clarity and coherence to*

the complex but critical matrix of teacher education activities, from initial recruitment as a student teacher, throughout the professional career of a teacher. The overriding aim of the policy is to properly equip teachers to undertake their essential and demanding tasks, to enable them to continually enhance their professional competence and performance, and to raise the esteem in which they are held by the people of South Africa". The Department of Education encourages and promote teachers in the pursuit of continuous teacher professional development as part of their lifelong learning journey. Furthermore, the policy holds that: *"Both conceptual and content knowledge and pedagogical knowledge are necessary for effective teaching, together with the teacher's willingness and ability to reflect on practice and learn from the learners' own experience of being taught. These attributes need to be integrated, so that teachers can confidently apply conceptual knowledge-in-practice"* (Department of Education, 2006, p. 16). Continuous TPD is necessary to enhance teachers' skills, not necessarily only their qualifications and also to deliver the Curriculum effectively, to strengthen their subject knowledge, their pedagogical content knowledge and their teaching skills.

Most Higher Education Institutions deliver continuous professional development to teachers by means of various academic programs, qualifications, short learning programs and workshops. It is within this context that a short learning programme on the infusion of Indigenous Knowledge into Technology Education was developed and delivered to in-service Technology teachers. The investigation was specifically in response to Gumbo's (2017, p. 155) call for research on the utilization of Indigenous Knowledge in Higher Education for teacher training. For Armour and Duncombe (2004), Armour and Yelling (2004) as well as Bechtel and O'Sullivan (2006), teachers are able to make connections between the professional development opportunity, their school and their classroom teaching. On the same note, King and Lawler (2003), as well as King and Newman (2001) point out that teachers' andragogical professional development is essential in gaining the necessary knowledge and skills needed to enhance the performance of their students in acquiring indigenous knowledge. South Africa, as a newly industrialized country, demands that teachers who engage in lifelong andragogical professional development, be well trained, actively participate in the era of the fourth industrial revolution, and simultaneously engage in being culturally responsive and treasuring the value contribution indigenous knowledge.

1.4.3 Decolonization of the Curriculum

Currently, there is an outcry in South Africa, as on the rest of the African Continent, for the decolonization and transformation of the Curriculum (Kamanzi, 2016). However, this discourse is often more politically inclined, and the question could be raised whether adequate attention

is given to aspects such as knowledge and cognition, pedagogy, and content regarding Curriculum implementation (Cronje, 2015).

The political discourse was placed centre-stage by the student protests of 2016. In political parlance, “decolonisation refers to the undoing of colonial governance when colonial countries attain independence” (Le Grange, 2019, p. 28). The political rhetoric focuses on putting systems in place for post-colonial education with the emphasis on disintegrating the wall between the “haves” and “have-nots”. Unfortunately there is little attention placed on the emancipating potential held by the infusion of the Indigenous Knowledge into the school Curriculum, as a possible means to decolonize the Curriculum. The term “decolonization” is defined by Klose (2011, p. 2) as *“the process whereby colonial rule dissolved in the periphery and in the metropole, with its various political, economic, cultural and social dimensions”*. Adopting a similar position, Waziyatawin and Yellow Bird (2012) wrote that decolonization can be expressed as the dynamic confrontation of the colonial powers that continue the suppression and/or manipulation of our minds, bodies, and lands. Wolff (2016) advises that decolonization of the Curriculum should not be assumed as unthinkingly exchanging some form of control for another. Rather, decolonization of the Curriculum should be regarded as an engaging meta-physical task of restructuring the Curriculum in such a manner that society can take pride in its relevance of addressing both social and educational challenges. For the purpose of this investigation, decolonisation refers to the ability of Technology teachers to transform, develop and use culturally specific teaching and learning strategies and implement such strategies to improve their teaching skills for the benefit of their learners. The innovative inclusion of Indigenous Knowledge into the Curriculum offers a pragmatic opportunity for the decolonization of the Technology Education Curriculum.

1.4.4 Origins and objectives of Technology as school subject

For decades, the South African education system mainly prepared learners for academic orientated occupations, while learners who wanted to pursue technological oriented occupations, were mostly neglected (Teis, 2014). This resulted in a chronic shortage of artisans in the country. In order to address this shortage of artisans for industry, Technology was established as a school subject during the post-1994 reformation of the Curriculum. The Department of Basic Education (2011, p. 8) defines Technology as: *“the use of knowledge, skills, values and resources to meet people’s needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration”*. The core content areas of the subject are: structures, systems, and control (mechanical and electrical), which include the processing of materials. For the purpose of this qualitative investigation, *Technology* refers to the school subject offered in the senior phase (Grades 7 to 9) of the South African School Curriculum, while *Technology Education* refers to the teaching and learning of the subject. The objective of Technology Education is to prepare learners, who aspire to pursue technological inclined careers within the fields of civil, electrical and mechanical technologies in the related industries. In order to arouse learners’ interest in the subject, Technology needs to be facilitated in a manner that makes sense to the learners within their social and environmental contexts (Department of Basic Education, 2011). Seleke, Havenga, and De Beer, (2019, p. 363) postulates that “because learners must make decisions, solve real-world problems, and apply appropriate practical skills, Technology Education promotes the development of innovation and critical thinking skills”. Moreover, it requires from learners “to understand and apply technological knowledge and cultivate various views on technology in society” (Department of Basic Education, 2011, p. 8).

Hill (1998, p. 204) defines Technology Education as *“the study of technology in elementary and secondary schools where students are provided the opportunity to use a variety of materials and processes to solve real-life technological problems; to develop technological skills and concepts and the ability to use tools (including computers); to acquire an understanding of various technological systems and processes; to evaluate the impact of technology on people and the environment; and to develop the confidence to be risk takers in technological problem solving”*. For Wicklien, Smith, and Kim (2009), Technology Education means a field of study that seeks to promote technological literacy for all students. Drawing from the New Zealand Ministry of Education (2007) example, Fox-Turnbull (2010) describes Technology Education as have been developed on the basis of practical and intellectual resources to the development of goods and systems that address human needs and realize opportunities. Dugger and Naik (2001, p. 31) maintain that Technology Education “is

concerned with the broad spectrum of technology, which encompasses, but is not limited to, such areas as: design, making, problem solving, technological systems, resources and materials, criteria and constraints, processes, controls, optimization and trade-offs, invention, and many other human topics dealing with human innovation". For Pudi (2007, p. 3), Technology Education "is a comprehensive experience-based educational programme that allows a learner to investigate and experience how people meet their needs and wants, to solve their problems and extend their capacities. This includes the use of knowledge and skills to develop, produce and use products or services and to assess the impact thereof on humanity".

What is quite distinctive about the cited definitions of Technology Education is that they resonate well with the definition of Technology as a school subject provided by the Department of Basic Education (DBE) who defines Technology as *"the use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration"* (Department of Basic Education, 2011, p. 8). The DBE (2011, p. 11) further adds that *"wherever applicable, learners should be made aware of different coexisting knowledge systems. They should learn how indigenous cultures have used specific materials and processes to satisfy needs, and become aware of indigenous intellectual property rights"*.

The implementation and utilisation of Indigenous Knowledge for the professional andragogical development of teachers hold the potential to transform Technology teachers into culturally responsive educators, with the necessary pedagogical knowledge and skills to serve the rich diversity of learners within their inclusive classrooms effectively (Ankiewicz, 2015; 2020).

1.4.5 Andragogical and pedagogical infusion of Indigenous Knowledge and Indigenous Technologies into Technology Education

Emeagwali (2014, p. 1) defines Indigenous Knowledge as: *"the cumulative body of strategies, practices, techniques, tools, intellectual resources, explanations, beliefs, and values accumulated over time in a particular locality, without the interference and impositions of external hegemonic forces"*. Gandile, Tessema and Nake (2017) elaborate that Indigenous Knowledge, which includes local knowledge, traditional knowledge, cultural knowledge, indigenous health knowledge, as well as indigenous technological knowledge, is knowledge that is culturally transferred over generations and time. Mapara (2009, p. 140) defines Indigenous Knowledge systems as *"a body of knowledge, or bodies of knowledge of the indigenous people of particular geographical areas that they have survived on for a very long*

time". For Quigley (2009, p. 79) the concept of Indigenous Knowledge (IK) refers to "*the acquisition of and practices that are developed by groups with long histories of intimate relationships with their natural environment*". In the same vein, Manyatsi (2011) considers IK to be the knowledge held by people of a particular cultural knowledge which include socioeconomic, politics and spirituality. Odora-Hoppers (2002, p. xx) notes that "*Indigenous Knowledge systems (IKS) are the total sum of the knowledge and skills which people in a particular geographic area possess, and which enables them to get the most out of their natural environment*". Throughout my research, I uphold the viewpoint that the "locus of indigenous knowledge' is inherently situated in genealogy, as a cultural repository, where such knowledge is connected, transferred, and extended from one generation to the next" (Seleke, Havenga, et al., 2019, p. 363).

South Africa, as a diverse country, has a rich storehouse of indigenous knowledges, customs, and rituals that influence how each culture handles unique issues (Seleke, Havenga, et al., 2019). Osaki (1994) lists the following categories of indigenous knowledge: (i) traditional herbal healing, (ii) traditional midwifery, sex, prediction of babies, (iii) treatment of animal diseases, (iv) crafts, including carving various goods, e.g. beehives, mugs, and stools, (v) clay pottery, (vi) water treatment through ashes, boiling, cooling and filtering, (vii) Food processing, preservation and storage, (viii) animal husbandry, e.g. castration and dehorning, (ix) making traditional make-up, (x) making soda ash for cooking and tobacco mix, and (xi) brewing and malting. Indigenous Knowledge is shared amongst members of a community by means oral narratives, participation in ordinary activities and rituals, including story-telling, practical demonstrations, recreation and sport activities, proverbs, metaphors and analogies, tales, recitations, poetry, riddles, songs, praise songs, puzzles, music, arts and crafts, dance, drumming, tongue twisters, word games, reasoning and debate, pottery, food preparation and preservation, beadwork, different ways of house constructing, and other forms of cultural activities and expressions (Gumbo, 2017; Ngara, 2007; Owusu-Ansha & Mji, 2013). A classic example of indigenous technology in terms of house construction, is the traditional "matjieshuise" of the Khoisan. This traditional dwelling is made from mats of *Cyperus marginatus* (Van Wyk & Gericke, 2018, p.374), In dry weather, the culms shrink, and this allows for air movement through the house's- natural 'air conditioning'. When it rains, the culms swell out, and make the house water proof (Van Wyk & Gericke, 2018). Indigenous technological knowledge is a distinct type of local understanding that includes behaviour and processes, as well as the creation of technological artefacts, as embodied in various traditions, communities, and types of heritage (Seleke, Havenga, et al., 2019).

According to Mapara (2009), embracing the worth and function of Indigenous Knowledge

systems (IKS) is an important step towards addressing many of the problems experienced by African countries who are completely dependent on Western forms of Technology Education curricula. Cronje (2015) posits that even though the South African Curriculum advocates for the inclusion of Indigenous Knowledge in the general education and training band, research shows that it often does not happen in practice. Most of the current cohort of Technology teachers lack the knowledge, pedagogy, and content to include Indigenous Knowledge into their pedagogical practices (Havenga, 2019). Technology, as a school subject, has the potential to inculcate technological literacy to capacitate citizens with appropriate knowledge and skills to operate sufficiently in the technologically inclined world (Gumbo, 2016; Heymans, 2007; Jain, 2006). As argued by Mapara (2009, p. 140): *“Africa is endowed with indigenous materials and technologies that could relieve Design and Technology related Curriculum systems in the continent... [i.e.] ...the burden of too much reliance on western systems of production that require modern materials, tools and equipment”*.

Abudu and Mensah (2016) argue that the design of the school Curriculum should be made more relevant and meaningful. The infusion of Indigenous Knowledge in Technology Education offers the opportunity to include practical knowledge in the teaching and learning of Technology (Briggs, 2005). This view is supported by Ankiewicz (2015), who maintains that Indigenous Knowledge (IK) is social, collaborative and cultural, and may, therefore, serve as a vehicle to advance 21st-century skills, such as collaboration, teamwork, creativity, critical thinking, and problem solving. Horsthemke (2015) believes that Indigenous Knowledge is elucidated in the practices, customs, and worldviews of a particular group of people, and refers to an alternative, non-formal kind of knowledge of those people. Adopting a similar position, Flor (2013) points out that for indigenous knowledge, traditional knowledge transfer protocols and epistemologies are followed. Quigley (2009, p. 79) reminds us that *“Indigenous Knowledge (IK) refers to the acquisition of and practices that are developed by groups with long histories of intimate relationships with their natural environment”*.

Although there is evidence of a willingness to instill Indigenous Knowledge in the South African Curriculum post-1994 Curriculum reforms (Cronje, 2015), Technology teachers still face challenges in incorporating Indigenous Knowledge in their classes. Several studies highlight challenges such as lack of appropriate teaching strategies for Technology Education, lack of appropriate teacher pedagogical content knowledge and lack of recognition of cultural diversity amongst learners as some hindrances facing Technology teaching and learning in South Africa (Pool, Reitsma, & Mentz, 2013; Teis, 2014). Supporting this view, Stein, Ginns and McDonald (2007) argue that the introduction of Technology Education in schools during the last decade, globally established a number of challenges for teachers. (Stein et al., 2007)

explain that these challenges are primarily related to Technology teachers coming to understand the phenomenon of technology and trying to conceptualize the Technology Curriculum in line with national frameworks. Stein *et al.* (2007) highlight the DBE's (2011) viewpoint that the vibrant character of the economy, manufacturing strains, as well as comprehensive scientific and technological knowledge, necessitate that the school Curriculum should be adapted according to the discipline of Technology Education. However, some authors (De Vries, 2012; Pudi, 2007; Stein *et al.*, 2007; Teis, 2014) have noted that teachers experience a lack of knowledge, scope, and breadth of Technology as a school subject, and as a result, regularly experience difficulties when trying to successfully plan and execute Technology Education lessons in their classrooms.

Indigenous Knowledge and technologies are pedagogically relevant and easily applicable to Technology Education, due to its' practical, cultural and social nature (Gumbo, 2015, 2016, 2017; Gumbo, 2018; Gumbo, 2019). According to Gumbo (2015, p. 70), the following are essential features of teachers who effectively infuse IK into Technology Education:

- (i) They need to accommodate all learners, regardless of their cultural contexts, as learners enrich teaching and learning activities with cultural nuances.
- (ii) They should mentor their peers, and need to interact with the community, in order to gain indigenous wisdom from the elders.
- (iii) Teachers and learners should engage in technological activities that recognise diverse cultural and social contexts, in order to find solutions for community- based problems.

1.4.6 Self-directed learning

Self-directed learning is defined by Knowles (1975, p. 19) as: “...*a process by which individuals take the initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes*”.

During the short learning programme, teachers were encouraged to develop their own self-directed learning skills, and to development goals for themselves. Louws, Meirink, Van Veen & Van Driel (2017, p. 172) state that “teachers show great ownership when directing their own learning in the workplace, it is of interest to explore what teachers themselves choose as their learning goals, what kind of learning activities they choose to engage in, and what reasons teachers have for professional learning”. Other researchers, such as Kyndt, Gijbels, Grosemans, & Donche (2016), agree with these sentiments, and therefore I have built the 16 credits Short Learning Programme (SLP) which is reported on in this study, on self-directed learning principles.

From the literature, it is clear that there are a number of teaching and learning strategies that hold promise in enhancing self-directed learning (De Beer & Gravett, 2016). Two such strategies are problem-based learning and cooperative learning- both aspects that are emphasized during the SLP(De Beer & Van Wyk, 2019).

1.5 Research Questions and Aims

Based on the above exposition, the central research question that guided this qualitative case study was:

What short learning programme design principles can be developed, based upon the qualitative findings of this investigation, for the infusion of Indigenous Knowledge into Technology Education, promoting both transfer in the classroom, and self-directed learning?

More specifically, sub-questions were:

- (i) How can Indigenous technologies be integrated and used in Higher Education as part of a short learning programme for the continuous professional development of senior phase Technology teachers?
- (ii) How can collaborative design and construction of indigenous bridge artefacts be optimally utilised to support the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education which simultaneously promote knowledge transfer and self-directed learning?
- (iii) What are the attitudes of senior phase Technology teachers towards the integration and use of indigenous technologies into Technology Education?
- (iv) What are the professional development needs of senior phase Technology teachers?
- (v) What challenges do they face when applying the newly acquired knowledge and skills in their classrooms?
- (vi) How do teachers apply the steps of Problem-Based Learning (PBL) in the design process, while acquiring Indigenous Knowledge and skills?
- (vii) How do Technology teachers develop SDL abilities amongst Technology teacher participants, while acquiring Indigenous Knowledge and skills?

By finding answers to the above stated research sub-questions, the following research sub-aims were successfully addressed:

- (i) To integrate and use Indigenous technologies in Higher Education as part of a short learning programme for the continuous professional development of senior phase Technology teachers.
- (ii) To explore how collaborative design and construction of indigenous bridge artefacts could be optimally utilized to support the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education which simultaneously promote knowledge transfer and self-directed learning.
- (iii) To explore the attitudes of senior phase Technology teachers towards the integration and use of indigenous technologies into Technology Education.
- (iv) To investigate the professional development needs of senior phase Technology teachers.
- (v) To identify the challenges that senior phase Technology teachers face when applying the newly acquired knowledge and skills in their classrooms.
- (vi) To investigate whether or not teachers apply the steps of Problem-Based Learning (PBL) in the design process, while acquiring Indigenous Knowledge and skills.
- (vii) To explore whether or not Technology teachers develop SDL abilities, while acquiring Indigenous Knowledge and skills.

And to successfully reach the central research aim of this qualitative case study, i.e.

To develop short learning programme design principles, based upon the qualitative findings of this investigation, for the infusion of Indigenous Knowledge into Technology Education, promoting both transfer in the classroom, and self-directed learning.

This case study's andragogical infusion of Indigenous Knowledge into Technology Education, contributes towards a larger research initiative, funded by the National Research Foundation (NRF), which also investigates the andragogical and pedagogical infusion of Indigenous Knowledge Systems into the Natural, Life- and Physical Sciences.

1.6 Research Design and Methodology

1.6.1 Design-Based Research Approach

I made use of a design-based research approach, consisting of three intervention cycles, pertaining to a short-learning programme delivered to senior phase Technology teachers, as part of their continuous professional development, on the infusion of Indigenous Knowledge into Technology Education. From these progressive intervention cycles, design principles were distilled for the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education. As posited by Collins, Joseph and Bielaczyc (2004), the design-based research approach was first introduced by Brown (1992) and Collins (1992), who made use of repeated cycles of design, implementation, analysis, and revision, within their research. A design-based research approach was ideal for my investigation, as it allowed me to develop and employ appropriate interventions, and at the same time, to cultivate theoretical knowledge to capacitate Technology teachers to infuse Indigenous Knowledge into their classrooms.

1.6.2 Qualitative Case Study Research Design and Methods of Data Collection

In order to reach an in-depth understanding of the attitudes, needs, challenges, and experiences of senior phase Technology teachers, who participated in a short learning programme for the infusion of Indigenous Knowledge into Technology Education, qualitative research was deemed appropriate for my study. Hancock (1998) argues that a qualitative research design is appropriate to obtain comprehension, examine the extent, fullness, and multiplicity that is deep-rooted in the aspect under investigation. Yin (2011, p. 9) adds that “*qualitative research strives to collect, integrate, and present data from a variety of sources of evidence as part of any given study*”. Accordingly, I followed a qualitative case study research design, and generated data using the following qualitative methods of data collection: (i) teachers’ self-reflective sheets, (ii) a focus group interview, (iii) photographic evidence, (iv) teachers’ indigenous technological artefacts, and (v) teachers’ collaborative mind maps.

1.6.3 Development of indigenous technological artefacts during a short learning programme

For the purpose of this qualitative case study I developed a short learning programme for the andragogical professional development of senior phase Technology teachers provided learning opportunities for participating teachers to integrate and use their culturally accumulated Indigenous Knowledge and skills, together with their design process skills in Technology Education. Teachers were also asked to solve community problems collaboratively by designing and constructing indigenous technological artefacts for given scenarios. The scenario presents an ill-structured problem from which a solution needs to be sought. As postulated by Voss (1988), Ill-structured problems are the replica of what learners

are confronted with in their everyday life. While developing accurate solutions for ill-structured problems, participants in this qualitative case study went through the following steps: a) define the problem, b) generate possible solutions, c) evaluate the alternative solutions by building arguments and articulating personal beliefs, d) implement the most viable solution, and e) monitor the implementation (Jonassen, 1997; Shin, Jonassen, & McGee, 2003), which are similar to the design process. During one of the learning activities of the short-learning programme that I presented to the five senior phase Technology teachers, participants collaboratively designed and constructed an indigenous bridge artefact, using dowel sticks, rope, and glue, in order to solve a community-based problem. In yet another hands-on learning activity, participants collaboratively created a mind-map reflecting their pedagogical use of Indigenous Knowledge to explain *food preservation*, as another core content area of the Curriculum.

1.6.4 Sampling

A purposefully selected availability sampling technique was used in this investigation to invite senior phase Technology teachers, who attended a short learning programme, to voluntarily and anonymously participate in this case study. Purposive sampling, according to Tongco (2007), is a method of non-probability sampling that is most useful when studying a specific cultural domain with experienced experts. In this qualitative case study, I used a design-based research approach, consisting of three intervention cycles (cycle 1 in Potchefstroom in 2017, and Cycle 2 in Calvinia in 2018, and Cycle 3 in Potchefstroom in 2019) pertaining to a short-learning programme, delivered to senior phase Technology teachers, on the infusion of Indigenous Knowledge into Technology Education. From these progressive intervention cycles, design principles are explained in Chapter 5 and can be used for the development of related short learning programmes in the future. The senior phase Technology teachers actively participated in various andragogical learning activities and exercises, over a period of three days, intended to stimulate the infusion of Indigenous Knowledge into Technology Education. At the end of the short learning programme, three of the Technology teachers (two males and one female, representative of two cultural-language groups) also participated in a focus group interview, in which I encouraged my participants to openly share their attitudes, needs, challenges, and experiences, with regard to their integration and use of Indigenous Knowledge and skills to attain “professional development into the core content areas in the senior phase Technology Curriculum” (Seleke, Havenga, et al., 2019).

1.6.5 Generation of a qualitative integrated dataset and qualitative data analysis

Using qualitative methods of data collection, I generated a combined integrated qualitative dataset consisting of: (i) teachers' self-reflective sheets, (ii) a focus group interview, (iii) photographic evidence, (iv) teachers' indigenous technological artefacts, and (v) teachers' collaborative mind maps. The focus group interviews were transcribed in order to allow for data analysis. I meticulously conducted qualitative data analysis, in the form of descriptive coding (Saldana, 2009), of my integrated dataset in order to group and organize data into interrelated data codes, categories, sub-themes and themes for the interpretation and discussion of my findings (Strauss & Corbin, 1998).

1.7 Trustworthiness and Credibility

The trustworthiness and credibility (Merriam, 2009) of the qualitative dataset, and the findings derived from the qualitative data analysis, was ensured through the following measures:

- Only practicing senior phase Technology teachers were invited to participate in the study.
- As main researcher, I am a university lecturer in Technology Education, with 15 years of actual Technology Education teaching experience on school level.
- Qualitative data was generated until data saturation was reached (Merriam, 2009).
- During the data analysis, a triangulation technique was employed to verify the accuracy of the data analysis and interpretation (Merriam, 2009).
- Any unclear data and findings were clarified by follow-up conversations with participants (Merriam, 2009).
- Member checking: the generated data and findings were presented to the participants in order for them to assess whether the recorded responses accurately reflect their own views (Maree, 2016).
- Triangulation of the categorical and thematic qualitative findings was done by means of two raters/data analysts, who each classified N themes into k mutually exclusive data categories. This was done in order to calculate Cohen's Kappa Coefficient (κ), as a measurement of inter-rater reliability, which also takes into account the possibility of agreement occurring by mere chance (Cohen, 1960).

This qualitative case study was furthermore guided by the following standards, as proposed by Eisenhart and Jurow (2011):

- Standard 1: I ensured a good fit between the research questions, data collection procedures and data analysis techniques.
- Standard 2: I provided good context for the study, in order to ensure that the reader of the

dissertation will have a good understanding of who the participants were, how data was collected, and what the features were that characterized the activity system.

- Standard 3: My own assumptions and biases were minimized during the research through triangulations and member checking.

1.8 Ethical Considerations and Funding

Ethical approval and clearance was obtained from our Higher Education Institution's Research Ethics Committee (NWU-00271-16-A2; and NWU-00791-18-S2), prior to the commencement of my qualitative case study. The former number refers to clearance for the larger NRF-funded project, of which my study forms part, and the latter number is specifically for my PhD study (refer to Addendum A for the ethical clearance certificates). Participants granted me formal permission and consent to use and analyze their data and to report the findings. Participants also gave me permission to take digital photographs of them during the short learning programme, and also to make use of and publish these photographic artefacts as visual evidence to support my qualitative findings. This qualitative case study forms part of a larger research initiative funded by the *National Research Foundation* and the *Fuchs Foundation*.

1.9 Chapter Divisions of this thesis

Table 1.1 outlines the chapter divisions of this research report:

Table 1.1: Chapter Divisions

Chapter 1:	Background and Orientation
Chapter 2:	Literature Review
Chapter 3:	Research Paradigms, Design, Methodology, and Qualitative Data Analysis
Chapter 4:	Findings of this Qualitative Case Study and Proposed short learning programme design principles, based upon the qualitative findings of this investigation, for the infusion of Indigenous Knowledge into Technology Education
Chapter 5:	Conclusions, Recommendations, Research Contribution and Limitations

Chapter 2

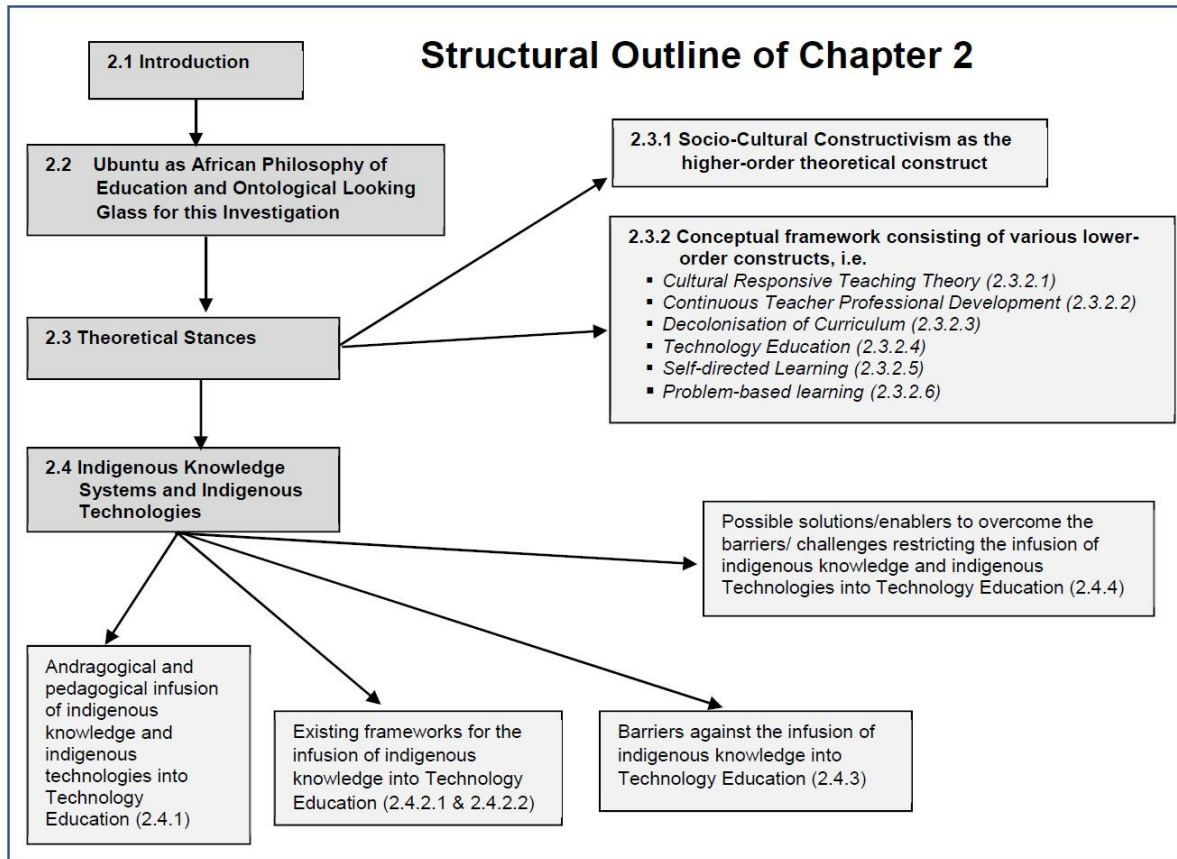
Literature Review

Motho ke motho ka batho ba bangwe

(A human can only be a human through other human beings)

Chapter 2

Literature Review



2.1. Introduction

The literature review in Chapter 2 reflects on the integration of Indigenous Knowledge into Technology Education. Firstly, *Ubuntu* - the African philosophy of Education, is described as the ontological looking glass through which I viewed, focused and interpreted my research. Then Social Constructivism is discussed as the higher order theoretical construct of my study, while a distinction is made between various lower order constructs, which together, constitute the conceptual framework of my research. The following lower-order constructs are explored in the literature: Cultural Responsive Theory, the continuous professional development of Technology teachers, the reformation and decolonization of the school Curriculum, the origins, core content areas and objectives of Technology Education in South Africa, self-directed learning, and problem-based learning. Next, Indigenous Knowledge Systems and Indigenous

Technologies are explored, followed by a discussion of the andragogic and pedagogical infusion of Indigenous Knowledge into Senior Phase Technology. Two existing frameworks for the infusion of Indigenous Knowledge into Technology Education are identified from the literature, i.e. (i) Gumbo's (2018) adaptation of Seemann's (2000) Technacy Framework for Technology Education, and (ii) the Cultural Responsive Teaching Theory Framework, first proposed by King, Artiles and Kozleski (2009), and later adapted by Gumbo (2018). The chapter continues to identify various barriers and challenges that still restrict the effective infusion of Indigenous Knowledge into Technology Education, while possible solutions to overcome these barriers and challenges, are also identified from the existing corpus of knowledge.

2.2. Ubuntu as African Philosophy of Education and Ontological Looking Glass for this Investigation

At its' heart, this research study strives towards the successful and effective inculcation of Indigenous Knowledge into Technology Education. The majority of learners and educators within the South African Education System are, like myself, from indigenous African descent. Hence, I viewed, focused, and interpreted my research from the African ontological perspective of Ubuntu. Table 2.1 provides Van der Walt's (1997, p. 29-34) ontological comparison between the Afrocentric worldview perspectives of Ubuntu, and the Eurocentric / Western worldview perspectives. These differences between the two ontological worldviews directly influence their ontologies (understandings of reality, i.e. their Worldview), their anthropologies (views of humankind), axiologies (norms and values), assumptions, attitudes, and experiences (Van der Walt, 1997, p. 29).

Table 2.1: Ontological comparison between the Afrocentric worldview perspectives of Ubuntu and the Eurocentric / Western worldview perspectives (Van der Walt, 1997, p. 29-34)

Afrocentric Worldview Perspectives of Ubuntu	Eurocentric / Western Worldview Perspectives
African Communalism	Western Individualism
Communal Self-Concept	Individual Self-Concept
Interdependence	Independence
Survival of the community	Survival of the individual
Group assurance	Personal gratification
Co-operation and harmony	Competition and conflict
Affiliation	Ownership

Afrocentric Worldview Perspectives of Ubuntu	Eurocentric / Western Worldview Perspectives
Focusses on shared duties	Focusses on individual rights
First the community, then the individual. (I am because we are. I share in the community; therefore, I exist.)	First the individual, then the community or social relationships. (We are because I am. The community exists because it is constituted by individuals.)
A high regard for the group, elevates it above the individual	A high regard for the individual, elevates it above the group
Like people (socially-centered)	Fear people (ego-centered)
Inclusive attitude	Exclusive attitude
Security	Loneliness
Dependence on people	Individual independence
Intense, strong personal relationships	Casual, impersonal interpersonal relationships
Open in social context	Closed in social context
Closed in inter-individual relationships	Open in inter-individual relationships
Group pressure strong	The opinion of the group is not so important
Individual initiative is not appreciated or encouraged – good human relations are a priority.	Individual initiative is highly
Co-operation.	Competition
Great degree of uniformity	Individual differences are preferred
Duties towards the community are emphasized.	The rights of the individual are stressed
The law has to restore social harmony	The law has to determine which individual is guilty/ innocent punishment is important, even through it causes bitterness at times.
Readily shares with others, generosity. (Venda proverb: Children share the head of a locust).	Acquisition for personal use, the danger of materialism
Eating is mainly a social event with a view to sharing food and discussion	Eating is mainly directed at acquiring new energy
Peaceful co-existence is highly regarded	Confrontation is not avoided at all costs
Dialogue: decisions have to be taken with approval of the group, and everybody has the opportunity to air views.	Monologue: decisions are often taken individually or by a few don't waste time through endless discussions!
Modesity, compliance, pliability, willingness to compromise character traits which lead to peaceful co-existence with one's fellow man (Westerners see this perhaps as a sign of dishonesty)	Honesty, frankness, incorruptibility, steadfastness and perseverance – all individual virtues. (The African might, as a result of these, regard the Westerner as being rude)

Afrocentric Worldview Perspectives of Ubuntu	Eurocentric / Western Worldview Perspectives
More causal and indirect way of asking and answering questions; would rather keep quiet than disturb relationships; prefers to give the answer one thinks the other would like hear	More direct questions and answers; if necessary, somebody is told the unmitigated truth – even if it hurts and is injurious to relationships.
Values such as friendliness, helpfulness, hospitality, a forgiving nature, patience and brotherliness are highly regarded.	Formality, independence, self-sufficiency, etc., are highly regarded
Poverty means that one does not have children or does not belong to a family.	Poverty is an indication that one (as an individual) does not have a large house, (expensive) car and (huge) salary.
People are important.	Things are important (possessions, buildings, machines)
Joy is experienced in social relationships	Joy is sought in possessions
A community-centered culture: be available to others.	A task-orientated culture: do something for others
Builds relationships by greeting people	Obtains information in greeting someone
Greet with a soft handshake, do not look each other in the eye.	Greet with a firm grip, looking the other straight in the eyes
Prefers to do things together	Prefers doing something yourself, on your own
It is not fitting to work for individual status – the norm is group status. (Good social character implies acceptance and guarantees status).	Strives for individual achievement and excellence. (For this reason, academic qualifications can provide status.
Salvation is acceptance by the group	A more individualistic concept of happiness and therefore also of the Biblical concept of salvation.
Responsibility is easily shifted on to the community – and everybody's responsibility easily becomes nobody's	Individual responsibility is emphasized.
Group egoism	Ordinary, individual egoism
Ethnic or tribal ethics or morality. Right means defending your own group and wrong means to sin against your own.	More universal ethics: any transgression against other individuals is therefore wrong.
Shame plays a more important role than guilt in ethics (it is important that people should not know that you erred, so that your public image should not be damaged)	Guilt is perhaps more important than a sense of shame (personal guilt is felt even though nobody else knows about it.
Tolerance and forgiveness, easier acceptance of other viewpoints and religions	More intolerant and inclined towards conflict – something is either true or false

Afrocentric Worldview Perspectives of Ubuntu	Eurocentric / Western Worldview Perspectives
Marriage is compulsory for all, needs the consent of the community and intended in the first place to engender children	Not such strong pressure to marry, and marriage is in the first place intended for the sake of the two individuals
Strong bonds with the extended family (many brothers, sisters, fathers and mothers)	Slacker bonds with a nuclear more mobile family
More personal communication by way of the spoken word (cf. riddles, proverbs, poetry, stories, dramas and song). Thus: oral tradition, strongly developed memory, danger of parroting in study	More impersonal modes of communication by means of the written, printed word and electronic media
Little personal space required	Huge personal space needed
Spend much time with other people.	Have little time for fellow humans

Ubuntu is an indigenous African philosophy of life and education, the soul of which is encapsulated in the Setswana proverb: “*motho ke motho ka batho ba bangwe*”, i.e. *a man can only be a man through other people* (Mbigi & Maree, 2005). The philosophy of *Ubuntu* is inherently collectivistic and communalistic in nature, with a high regard for the group, opposed to Western philosophy’s predisposition towards Individualism and Secularism, with a high regard for the individual (Mbiti, 1969). *Ubuntu* holds that: “*I am because of the other, my existence is not in isolation from my society. The wellbeing of the entire society is intertwined in co- existence with its citizens in such a way that one cannot exist without the other*” (Mabovula, 2011). *Ubuntu* furthermore advocates that we all need each other in order to make sense of the world, we learn best through collaborative efforts to achieve outcomes are community-based, as education and culture are considered to form an interconnected and interdependent unity (Gumbo, 2014; Oelofsen, 2015). The relevance of *Ubuntu* as a philosophy of education, was mostly undervalued in the past (Gwekwerere 2016; Taylor, 2014a). *Ubuntu* was not recognized as a philosophy of education, and the Western philosophies and pedagogies of Education were forced down upon African learners. However, more recently, *Ubuntu* became widely recognized as the ontological nexus and driving force behind the educational movement towards the decolonization of Curriculums and the re-visioning of education throughout the African continent (Mbiti, 1969; Obanya, 2018; Takyi-Amoako & Assie-Lumumba, 2018). A growing number of African scholars (Emeagwali, 2014; Gumbo, 2014; Gwekwerere 2016; Le Grange, 2012; Lutz, 2009; Metz, 2007) are sharing

the same vision to regain the education that Africa lost as a result of its' colonization. According to Obanya (2018), indigenous African education is based upon the following educational principles:

- (i) "Culture is the cornerstone of education.
- (II) An all-inclusive education system of life-long learning, mapped out according to the developmental stages of life.
- (III) Articulation of education through informal and diverse routes to learning.
- (IV) Emphasis is placed on gaining life skills based upon the normal and organizational patterns and modes of society and culture.
- (V) Social recognition and a high regard for educators as knowledgeable and skilled members of the community.
- (VI) The use of socially accepted pedagogy, e.g. oral communication, instructing, demonstrating, encouragement and admonishment, repetition, team/group teaching and collaborative learning, internships and apprenticeships" (Obanya, 2018, pp. 87-90).

2.3. Theoretical Stances

For the purpose of my qualitative case study, I used Socio-Cultural Constructivism as the higher-order theoretical construct of my study, while I furthermore distinguished between various lower-order constructs, which together made up the conceptual framework of my research.

2.3.1. Socio-Cultural Constructivism as the higher-order theoretical construct

Theoretical framework can be defined as *"a structure that guides research by relying on a formal theory...constructed by using an established, coherent explanation of certain phenomena and relationships"* (Eisenhart, 1991, p. 205). In their discussion on the importance of theoretical frameworks in research, Grant and Osanloo (2014, p. 12) avers that a theoretical framework provides *"a grounding base, or an anchor, for the literature review, and most importantly, the methods and analysis"*. As part of my qualitative case study, I created and presented a short learning programme for the continuous professional growth of Technology teachers with respect to the infusion of indigenous expertise into Senior Phase Technology Education, which is underpinned by Socio-Cultural Constructivism.

Schreiber and Valle (2013, p. 396) define Social constructivism *"as a branch of constructivist thought, which holds that knowledge is individually constructed via one's experiences"*. Social constructivism should be considered as a knowledge theory that asserts that people's

understanding and interpretations of the world are co-constructed (Amineh & Asl, 2015). Most social constructionists view knowledge as being constructed, opposed to being created (Andrews, 2012; Galbin, 2014; Kim, 2001). The significance of social constructivist theory in education is that social collaborations are pivotal in the construction of knowledge (Amineh & Davatgari, 2015).

Perhaps the greatest advantage of social constructivism as a theory of education is that it was strongly avowed by the work of Vygotsky (1978), which holds that knowledge is initially constructed, adopted and practiced by people in social settings (Galbin, 2014; Tayebbeh & Ghaemib, 2011). Learning is viewed as a dynamic practice through which learners ascertain philosophies, models and realities for themselves in their natural environment (Berger & Luckmann, 1966). According to Schwandt (1994, p. 118), constructivist research has been instrumental in understanding the complex world of lived experiences (phenomenology), from the point of view of those who live it. Hausfather (1996) and Wertsch and Sohmer (1995), reported that Vygotsky's socio-historical method for perceptive growth, affords the reinforcement for social constructivism in the classroom. Adams (2006) posits that knowledge construction cannot be disconnected from the social environment from which it is molded. As mentioned in chapter one, existing research recognizes *Socio-Cultural Constructivism* as a branch of constructivists theory with similarities to social constructivism (Stauffer, Walter, Lang, Wiek, & Scholz, 2006). According to Stauffer et al. (2006), the general constructivist theory of socio-cultural pedagogy is drawn from the works of Piaget (1954), Bruner (1966), Resnick (1987), and Vygotsky (1978). Building further upon these theories, Bruner (1990) placed specific emphasis on the political, cultural, and social contexts of pedagogy.

Socio-Cultural Constructivism is important in social research because of its position to foster broader understanding of the development, association, and conversion of perceptual developments in a broad-spectrum (Rengifo-Herrera & Uchoa Branco, 2014). I agree with Vygotsky (1978), who advocated that culture is strongly linked to "metacognitive processes". Cole and Wertsch (1996, p. 255) also maintain that "*higher mental functions are, by definition, culturally mediated*". Drawing from the Socio-Cultural Constructivism perspective, the design and facilitation of a short learning programme for the infusion of indigenous knowledge, allowed the Technology teachers in my study the opportunity to draw knowledge and skills from their culturally accumulated ancestral memory, in order to cooperatively find solutions for community-based problem scenarios. This is in accordance with Vygotsky (1988), who believed that the origin of social behaviour is derived from past inter-personal experiences and cultural semiotics, as well as with Bruner (1986; 1990; 1996) who considers cognition as a dynamic, situated and contextual process through which new knowledge is linked to previous experience.

For Hutchison (2006), the creation of knowledge happens within a “cultural vessel”, and nature, by its character, is the arbitrator of such creation. Therefore, it is important for Technology teachers to acknowledge the diverse cultural backgrounds of their students, in order to adequately infuse Indigenous Knowledge in their classrooms. Similarly, Hutchinson (2006, p. 308) argues that: *“teachers of diverse student backgrounds therefore need to be sensitive to their students’ backgrounds and what they bring to the classroom to ‘fill-in- the blank”*. Within multicultural classrooms, students bring a rich cultural diversity with them to the class, which can be tapped into and contextualized for the purpose of infusing Indigenous Knowledge in Technology Education. It is within this context that a de-colonial agenda could be set in order to achieve epistemological border crossing between the western knowledge systems and indigenous knowledge. According to Moretti (1998), the epistemological border is the border on the plane of knowledge: the border between the known and the unknown. That which lies on the other side of, for example African indigenous knowledge, is often perceived by Western knowledge systems as unknown. “The border and the border zone, because of its hybrid, ambivalent status, can also be perceived as being unknown and thus on the other side of an epistemological border.” (Moretti, 1998, p. 45). The intention of this qualitative case study was to promote and establish an epistemological border crossing between Indigenous Knowledge and western world views in Technology Education.

I furthermore agree with Pohawpatchoko (2018, p. 2) that *“the inclusion of culture provides a more holistic understanding of the Indigenous experience*. By taking the cultural diversity of students into account during the infusion of Indigenous Knowledge in Technology Education, lays fertile ground for epistemological pluralism, while multiple ways of learning and knowing are recognized (Hutchison, 2006; Piaget, 1954, 1970; Pohawpatchoko, 2018). From Vygotsky’s social constructivism, emerged the concept of the *Zone of Proximal Development (ZPD)*, which is discussed in Section 2.4.4.7 below. Vygotsky (1978) stated that learning occurs on two levels or planes. The first level, is where learners, in a social setting, construct knowledge together. During the SLP, this typically happened during the different activities that teachers engaged with. On the second level, every individual teacher internalized this knowledge, while reflecting on the knowledge (e.g., while compiling their growth portfolios).

2.3.2. Conceptual framework consisting of various lower-order constructs

Besides applying social constructivism as the higher-order theoretical construct of my research, I furthermore distinguished between various lower-order constructs, which together constituted the conceptual framework of my qualitative case study. My conceptual framework

could be compared to what Engestrom (2011) calls 'intermediate theories'. Accordingly, this section provides an overview of the central intermediate theories that guided my research.

2.3.2.1. Cultural Responsive Teaching Theory

As already elaborated upon in the first chapter (Section 1.4.1), and also stated in Section 2.4.2.3 below, I applied Gumbo's (2018) adaptation of King, Artiles and Kozleski's (2009) Cultural Responsive Teaching Theory Framework, to the unique context of my qualitative case study, in order to develop and deliver a short learning programme for the continuous professional development of Senior Phase Technology teachers, with regard to the infusion of Indigenous Knowledge into Technology Education.

2.3.2.2. Continuous teacher professional development for Technology Education

The South African Department of Basic Education (DBE) put a policy framework in place, in order to ensure that teachers meet the educational demands of the 21st century. The National Policy Framework for Teacher Education and Development in South Africa (Department of Education, 2006, p. 4):

"...is designed to develop a teaching profession ready and able to meet the needs of a democratic South Africa in the 21st century. It brings clarity and coherence to the complex but critical matrix of teacher education activities, from initial recruitment as a student teacher, throughout the professional career of a teacher. The overriding aim of the policy is to properly equip teachers to undertake their essential and demanding tasks, to enable them to continually enhance their professional competence and performance, and to raise the esteem in which they are held by the people of South Africa".

The Department of Education encourages and promote teachers in the pursuit of continuous teacher professional development as part of their lifelong learning journey. According to the National Policy Framework for Teacher Education and Development (Department of Education, 2006, p. 16):

"Both conceptual and content knowledge and pedagogical knowledge are necessary for effective teaching, together with the teacher's willingness and ability to reflect on practice and learn from the learners' own experience of being taught. These attributes need to be integrated, so that teachers can confidently apply conceptual knowledge-in-practice"

Continuous teacher professional development (TPD) is necessary for the effective and progressive delivery of the school Curriculum, by strengthening teachers' subject knowledge, their pedagogical content knowledge, as well as their teaching skills. Accordingly, most Higher Education Institutions deliver continuous TPD to teachers by means of various academic programs, qualifications, short learning programs and workshops. It is within this context that I developed and delivered a short learning programme on the infusion of Indigenous Knowledge into Technology Education. For Armour and Duncombe (2004), Armour and

Yelling (2004), as well as Bechtel and O'Sullivan (2006), teachers should be able to make connections between TPD opportunities, their school, and their classroom pedagogical practices. On the same note, authors like King and Lawler (2003), and King and Newman (2001) stress that TPD is essential for teachers to gain the necessary knowledge and skills that they need, in order to enhance the academic performance of their learners, e.g. through the infusion of Indigenous Knowledge into Technology Education. South Africa, as a newly industrialized country, demands from teachers to actively engage in lifelong andragogic professional development, to be well trained, to actively participate in the fourth industrial revolution era, and simultaneously, to engage in being culturally responsive and treasuring the value contribution of indigenous knowledge. TPD is therefore crucial to enable teachers to use their newly gained knowledge and skills to also improve the achievement of their learners (Carr et al., 2000). TPD offers more practical ways for teachers to introduce new content, new teaching and learning strategies, as well as new ways of assessment into their classrooms, with the aim to achieve pedagogical and Curriculum reformation. Across the globe, a growing number of countries are prioritizing TPD to empower their teaching force (Mokhele & Jita, 2010). Accordingly, my qualitative case study is a direct response to Gumbo's (2017, p. 155) call for research on the utilization of Indigenous Knowledge by HEI for the purpose of delivering continuous TPD for Technology Education. . In order to exploratory support for TPD, Rogan and Grayson (2003) developed a profile of implementation (in the context of science education) which consisted of four domains (i.e. classroom interaction, science and practical work, science and society, and assessment) which can be measured by four levels (level 1 to 4), with Petersen and De Beer (2012) who added a level zero because some teachers do not even operate on the lowest conceptualized level 1. Sebotsa, De Beer and Kriek (2019) furthermore included self-directed learning abilities, as a fifth domain. This is also a useful heuristic for the professional development of Technology teachers, as Technology is part of the STEM subjects. In the current investigation, Rogan and Grayson's profile of implementation is adapted to include problem-based learning approach to infuse indigenous knowledge. Table 2.2 below provides progressive levels of Technology teachers' professional development with regard to classroom interaction, practical work, technology and society, assessment skills, self-directed learning and problem-based learning skills (adapted from Rogan and Grayson (2003), together with self-directed learning skills conceptualized by Sebotsa et.al (2019), and professional development levels for problem-based learning skills, proposed by this study. Table 4.8 (in Chapter 4) presents a heuristic matrix mapping of Technology teachers' pre- and post-intervention levels of professional development pertaining to the third intervention cycle of this investigation.

Table 2.2: Progressive levels of Technology teachers' professional development with regard to classroom interaction, practical work, technology and society, assessment skills, self-directed learning and problem-based learning skills (adapted from Rogan and Grayson (2003), together with self-directed learning skills conceptualised by Sebotsa et al (2019)), and professional development levels for problem-based learning skills, proposed by this study.

Levels	Classroom interaction	Technology practical work	Technology in society	Assessment	Teachers self-directed learning	Problem based learning
0	Teachers presents transmission-type lesson in an unstructured way and reads mostly from the textbook; Limited and ineffective media usage; Learners passive and not engaged.	Practical work is seldom done; Teacher uses limited and not well-planned demonstrations to assist in the explanation of concepts.	Teacher seldom uses examples from the learner's daily lives, and if used there are incoherent.	Written tests on lower cognitive levels; Tests marked and handed out to learners.	There is no evidence of SDL; the teacher does not show Interest in ongoing professional activities.	Teachers are unable to conceive, comprehend, or apprehend teaching strategies or learning activities, for which Indigenous Knowledge could possibly be used to solve community-based learning problems, by following a problem-based learning approach.
1	Teacher presents organized lessons; Uses textbook effectively; Learners are engaged and respond to questions.	Teacher uses classroom demonstrations to help develop concepts.	Teachers uses examples from everyday life to illustrate scientific / technological concepts.	Written tests are given; most questions of recall type; most tests marked and returned promptly.	There is minimal evidence of SDL; the teacher indicates that he/she has professional development needs, but there are no concrete learning goals identified.	Teacher demonstrates very little knowledge and skills concerning problem-based learning strategies that could possibly be used to guide learners towards applying Indigenous Knowledge to solve community-based learning problems. Teacher struggles to formulate learning goals and activities.

Levels	Classroom interaction	Technology practical work	Technology in society	Assessment	Teachers self-directed learning	Problem based learning
2	Textbook used along with other resources; engages learners with questions that encourage deeper thinking and meaningful group work.	Teachers uses demonstrations to promote a limited form of inquiry; learners participate in 'cookery book' practical work.	Teacher bases lessons on specific problem faced by community.	Written tests include 50% of higher cognitive level questions.	The teacher formulated learning goals, but there is limited evidence that learning resources or learning strategies were identified.	Teacher demonstrates the basic ability to conceive community-based learning problems and outcomes that would allow learners the opportunity to find solutions by applying their Indigenous Knowledge for problem-based learning.
3	Teacher structures learning along 'best practice' lines; learners engage in minds-on learning activities.	Practical work to encourage learner discovery of information.	Learners actively investigate the application of science & technology in their own environment.	Written tests include 'guided discovery' – type activities; Assessment includes other forms such as reports.	There is clear evidence of SDL; learning goals, resources and applicable strategies were identified. However, there is no evidence of evaluating the learning actions.	Teacher demonstrates the ability to create an enabling learning environment, and to successfully engage their learners in problem-based learning activities, directed towards solving community-based learning problems through the application of indigenous knowledge.
4	Learners take major responsibility for own learning and undertake long-term investigations and projects; Teacher facilitates learning.	Learners design and do open investigations.	Learners actively undertake a project in their local community and explore long-term effects of community projects	Open investigation and community-based projects included in final assessment; learners create portfolios.	Strong evidence that the teacher is self-directed i.e. the teacher can define his or her own goals, goals related to central need, able to set path to achieve the goal, the goal is realistic not too high	Clear evidence that learners take responsibility for their own problem-based learning, directed towards solving community-based

Levels	Classroom interaction	Technology practical work	Technology in society	Assessment	Teachers self-directed learning	Problem based learning
					or too low, but enough to be challenging, and the teacher evaluates whether the learning goals were achieved. The teacher promotes SDL in his/her classroom.	learning problems, by effectively conceiving, comprehending, and apprehending ways in which they could apply and utilize indigenous knowledge to find solutions.

2.3.2.3. Reformation and Decolonisation of the School Curriculum

With recent discussions about the need to decolonize the South Africa's Curriculum, there is a need for more dialogue. This is because each culture claims some form of entitlement to a form of knowledge or another. Most Africans believe that they have been colonised, and as a result of colonisation, abandoned their cultural knowledge of their indigenous identity. The question can be raised what decolonization is? My first point concerns not power, but compromise and inclusion. To decolonise a Curriculum, one must know what decolonization is, one should accept changes, and one should be pragmatic in a manner that recognizes epistemological equality between Indigenous ways of knowing and Western philosophies. This is not entirely surprising; it really is a complicated, complex and conflicting process of decolonization. I discovered that the definitions of "decolonization" and who is "Indigenous" remains, for the most part, open and to some extent unknown, despite their centrality in many research studies (Sium, Desai, & Ritskes, 2012).

Decolonization also includes radical changes experienced by colonised countries when they become politically independent of their former colonisers (Fomunyam, 2017). To counteract the legacy of colonialism, the epistemological landscape of the country in question, must also be decolonized and, undoubtedly, the mind of the formerly colonised should be decolonised (Oelofsen, 2015). There is no decolonisation outside the paradigm that pivots around and favors indigenous life, community, and epistemology (Sium et al., 2012). This removes decolonisation from the political or traditional notion of decolonisation (which implies the process in order to relinquish control of a territory by the colonizer to the colonized), to the more robust complexity of removing colonial legacies from the educational system, with regard to content that is ideologically driven. It isn't just a case of being naive in rejecting the "old" Eurocentric and Westernized information and education frameworks and then assuming a new program, in essence, Curriculum designers must provide realistic solutions for a contextually appropriate Curriculum that disrupts dominant Westernised information structures and replaces them with Indigenous Knowledge systems (Mahabeer, 2018). Indigenous Knowledge is an important tool to decolonize the Technology Education Curriculum. The goal of this research is located clearly in what Balfour (2019, p. xxxvii) describes as "nascent scholarship concerning the decolonisation of the Curriculum (in fields beyond postcolonial literary studies), and positioning Indigenous Knowledge systems as a means through which Curriculum and Curriculum making, pedagogy and teaching methodologies come to be revisioned".

2.3.2.4 Origins, core-content areas and objectives of the subject Technology in South Africa

Technology Education is still relatively new on a worldwide scale, and it lacks a solid research foundation, a well-established classroom methodology, and a scientifically informed, subject-based philosophical framework that may serve as a guideline for associated issues (Ankiewicz, 2015a). According to Ankiewicz (2015a; 2015b), Technology is likewise an emerging school subject within the context of South African curriculum, with no analogous academic discipline on which to base curriculum development and classroom methodology. Technology was introduced as a school subject in South Africa as a result of post- Apartheid Curriculum reformation, in order to respond to the technical needs of the global economy (Stevens, 2006).

The rationale for the introduction of Technology as school subject, according to the South African Department of Basic Education (DBE), was to give rise to engineers, technicians, and artisans required in present-day society (Department of Basic Education, 2011). The DBE Curriculum and Assessment Policy Statement (CAPS) posits that the subject stimulates learners to be innovative and develops their creative and critical thinking skills. The document also states that Technology Education teaches learners to manage time and material resources effectively, provides opportunities for collaborative learning and nurtures teamwork (Department of Basic Education, 2011). However, since its implementation, Technology Education has undergone numerous reforms. Currently, it is taught in intermediate, senior and FET phases of the South African school Curriculum to prepare learners for the world of work. Table 2.3 (that follows) shows the themes and sub-themes of the Technology Education Curriculum.

The Technology Education Curriculum also expanded to include South Africa's wealth of Indigenous Knowledge (Cronje, 2015). The DBE strongly encourages the inclusion of IK contending that "wherever applicable, learners should be made aware of different coexisting knowledge systems. They should learn how indigenous cultures have used specific materials and processes to satisfy needs, and become aware of indigenous intellectual property rights" (Department of Basic Education, (Department of Basic Education, 2011, p. 11)). The infusion of IK in the Technology Education Curriculum has the potential to make teaching more relevant to the lived and cultural experiences of learners (Muchenje & Pedzisai, 2013). The "technological design process comprises skills such as investigation, design, making, evaluation and communication. Knowledge of structures and materials are also essential. Moreover, the Curriculum requires from learners to understand and apply technological knowledge and cultivate various views on technology in society (CAPS, 2011)" (Seleke, Havenga, et al., 2019, p. 363). Table 2.3 below provide a summary of themes and sub-themes

for senior phase Technology Education as prescribed in the CAPS document.

Table 2.3: Themes and sub-themes of the Technology Education Curriculum according to Mapotse and Gumbo (2020, pp. 72-73)

No	Theme	Sub-theme	Skills needed
1	Design Process skills	Investigation Design Making Evaluation communication	All the sections of the design process are skills to be learnt by learners
IDMEC(Investigate, design, make, evaluate and communicate) is the method of teaching for Technology Education and should be given a weighting of 50 percent for tests and examinations in grade Grades 7-9)			
2	Structures	Definition and purposes(to contain, Protect, support, span) Classification(Natural and man-made) Types (shell, frame, solid) Structural members Forces on structures Types of loads	Action research (strengthening techniques skills) Case study (investigating skills) Class discussion (design skills)
Structures is one of Technology Education's core content knowledge area to be taught per phase per grade and should share a weight of 50 percent with themes 3, 4 and 5.			
3	Processing of materials	Preserving metals(painting, galvanizing, electroplating) Preserving food(storing grain, pickling, drying and/or salting Plastics properties(reduce, reuse, recycle)	
Processing of materials is one of Technology Education's core content knowledge area to be taught per phase per grade (grade 7-9) and should share a weight of 50 percent with themes 2, 4 and 5.			
4	Mechanical systems and control	Simple mechanisms (levers, linkages, hydraulics, pneumatics) Gear systems (counter-rotation, idler, velocity ratio, force multiplication) Mechanical advantage calculations	Action research on Pascal's principle (gases and liquids)
Mechanical systems and control is one of Technology Education's core content knowledge area to be taught per phase per grade (grade 7-9) and should share a weight of 50 percent with themes 2, 3 and 5.			
5	Electrical/electronic systems and control	Simple electrical circuit components Series and parallel connections Input devices(electrochemical cell, generator, solar panel) Output devices (resistor, lamp, heater, buzzer, motor) control devices (switches) types of cells and power stations DC and AC current Logic gates Resistor colour codes Simple electronic circuit component	Action research on testing Ohm's law practically
Electrical/electronic systems and control is one of Technology Education's core content knowledge area to be taught per phase per grade (grade 7-9) and should share a weight of 50 percent with themes 2, 3 and 4.			
6	Technology, Society and the environment	Indigenous knowledge Impact of technology Bias in technology	Critical thinking skills, negotiation skills, co-operation skills, etc.
Indigenous knowledge, impact of technology, bias in technology are all the Technology Education values and attitudes that should be inculcated in learners. Together, they should be given a weighting of 20 percent in test and examinations.			

Ankiewicz, (2015a) advises that to make impartial judgements concerning such Technology Education curricula, is impossible. It is critical to emphasize that curriculum writers and evaluators should be aware of the philosophical framework for Technology that informs subject-curriculum creation and assessment, (Ankiewicz, 2015a). In his seminal works, Ankiewicz, (2013a; 2013b; 2015a; 2015b) has demonstrated that Technology may be differentiated as knowledge (epistemology), based on distinct forms of knowledge, namely conceptual (knowing that) and procedural (knowing how [to know how]). Ankiewicz (2013a; 2013b; 2015a; 2015b) distinguish between four constructs related to Technology as a subject:

- (a) Ontology: From an ontological perspective, Technology reflects a number of universal characteristics, e.g. it is a phenomenon unique to humans, employing tools, to deliver products or processes (p. 320).
- (b) Epistemology: We should distinguish between the substantive nature of Technology (the conceptual knowledge), and the syntactical nature of Technology (the procedural knowledge).
- (c) Methodology: Various kinds of complex thinking processes (creative and critical thinking, decision-making and problem-solving) underpin Technological activities (p. 323).
- (d) Volition: Technologies are associated with a wide array of volitional activities, e.g., drives, motivation, aspiration and intentions (p. 324).

According to Ankiewicz (2013c, p. 317), the nature of the link between natural science knowledge and Technology knowledge is an epistemological issue that regularly comes to the fore (Ankiewicz, De Swardt & De Vries, 2006). Those who follow the positivist school in natural science philosophy would argue that Technology is truly applied science, i.e. the accepted viewpoint of engineers and scientists, and of Mario Bunge, as their strongest philosopher. Ankiewicz (2013c) points to the fact that they would attempt to construct a technological epistemology based on an all-encompassing model based on scientific laws for its explanatory capacity (Mitcham, 1994). In contrast to Bunge's view of Technology as applied science, there is also the notion that there is no deducible relation between one or more elements of technical knowledge and natural science, or that they are completely incompatible (Mitcham, 1994). Rauscher (2012) stresses that an educational approach, which follows a Technology-is-applied-science model, might result in a misrepresentation of the historical and epistemological relationship between natural science and Technology. This might also present an inaccurate image of the nature of Technology as activity/methodology. One should therefore be cautious to rely on the view of Technology as 'the application of science', and to use it as a traceable anchor of an academic discipline for Technology.

In the first part of Table 2.4, I summarised Ankiewicz's (2013c, p. 317-336) application of Mitcham's (1994) Philosophical Framework for Technology to evaluate Technology intended for the Senior Phase Technology Curriculum (CAPS), and then, following in the footsteps of Ankiewicz's (2013c), I propose in the second part of Table 2.4, the application of the same framework to evaluate Technology intended for future short-learning programmes on the infusion of indigenous technology into Senior Phase Technology Education.

Table 2.4: Comparing Ankiewicz's (2013c, p. 317-336) application of Mitcham's (1994) Philosophical Framework for Technology with the current study's proposed application of the same framework

	Ankiewicz's (2013c, p. 317-336) application of Mitcham's (1994) Philosophical Framework for Technology, to evaluate Technology intended for the Senior Phase Technology Curriculum (CAPS)	The current study's proposed application of Mitcham's (1994) Philosophical Framework for Technology, following Ankiewicz's (2013c, p. 317-336) insights, to evaluate Technology intended for future short-learning programmes on the infusion of indigenous knowledge into Senior Phase Technology Education.
Ontology	Ankiewicz, (2013c, p. 317-336) applied the four modes of Mitcham's (1994) Philosophical Framework for Technology, to evaluate Technology intended for Senior Phase Technology Curriculum (CAPS). Ankiewicz (2013c), cited a number of scientists who have looked into the philosophical frame work for Technology, his arguments are mainly derived from Mitcham (1994). Ankiewicz (2013c) points to the fact that within the educational environment, there is no one relevant academic discipline that may serve as a basis for curriculum design and development for the subject Technology. This is backed up by the fact that, by characterization, nearly every school subject in Senior Phase may be found embedded within in the subject Technology in the context of the South African school curriculum. His submission is in highlighting the supposition by Mitcham that the most direct, if not the simplest, manner in which Technology is found embodied is as an object, which can include any human-made objects whose function is dependent on a certain material. What stood out for me is that Ankiewicz (2013c, p. 320) identified the following essential traits or universal characteristics of Technology from the works of Dekker, (1982) and Van Schalkwyk,(1996): ▪ “a phenomenon unique to humans; ▪ employed by using tools ▪ a way of human form creation; ▪ giving form to nature; ▪ for human purposes; ▪ to deliver a product or process;	Future short-learning programmes on the integration of indigenous knowledge into Senior Phase Technology Education, should include indigenous Technologies from the local communities. Participants should be motivated to apply theoretical principles to their daily lives, as a result of this inclusion of local indigenous Technologies. This is a unique opportunity for the transfer of local indigenous knowledge and skills drawn from local people in the communities (see Section 1.4 and Figure 1.3 above, as well as Section 2.4 and Table 2.5 below).

	▪ being determined by world views” All specialized forms of Technology must possess these essential features of Technology as a universal phenomenon, otherwise they are not to be considered as true forms of Technology. According to Ankiewicz (2013c, pp. 320-321): “ things that are produced by animals, such as bird nests, spider webs and beaver dams and which share certain characteristics with artefacts (Mitcham, 1994), are not classified as technology because one of the fundamental characteristics of technology is that it is a human phenomenon (Mitcham, 1994). Without man there would have been no technology”. The philosophy of Technology assists in the placement of Technology Education amongst other disciplines. As a result, it is important to guarantee that the anticipated Technology is consistent to the ontology of Technology when reviewing the planned Technology curriculum (Ankiewicz, 2013c). As a result, it is important according to Ankiewicz (2013c), to guarantee that the supposed Technology is loyal to the ontology of Technology when reviewing the planned Technology curriculum, that is, that what is provided in Technology classes is, in essence, Technology and not something else, such as applied science.	According to the traditional African ontology of Ubuntu, man and animals are all part of Nature, and therefore, man cannot be regarded as separated from Nature (Mbiti, 1969). From the viewpoint of Ubuntu, I disagree with Mitcham’s (1994) argument that: “ things that are produced by animals, such as bird nests, spider webs and beaver dams and which share certain characteristics with artefacts, are not classified as technology because one of the fundamental characteristics of technology is that it is a human phenomenon” (Ankiewicz, 2013c, pp. 320-321). Man can learn from the wisdom of animals, and many African tales of animals are orally used to teach some form of wisdom to people. According to Mitcham’s argument, the wings of an aeroplane should therefore not be considered as Technology, as they resembles the wings of birds. Figure 2.4 under Section 2.4 below, tell of a symbiotic relationship that the Leghoya people had with Nature, in which they attracted ants to their fields of millet using bruised and buried bones, in order to save their harvests from being destroyed by other insects. This is yet another example in favour of my argument against Mitcham’s viewpoint which regards man as a unique being who is separated from the rest of Nature.
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Epistemology

Ankiewicz (2013c) further states that the second form of expression of Technology is Technology as knowledge, which frequently been the subject of analytical inquiry in epistemology or theory of knowing, according to Mitcham. Technology epistemology is based on theoretical thoughts and, more recently, pragmatic investigations. Several types of knowledge, such as maxims, norms, and theories, can be used to differentiate technology as knowledge. Although conceptual and procedural knowledge are differentiated in Technology, these two forms of knowledge are inextricably linked. Conceptual or descriptive knowledge refers to the linkages between knowledge objects, to such a degree that when learners can recognize these relationships, it is considered that they demonstrate conceptual proficiency.

Knowledge of Technology as objects is obviously conceptual knowledge that may be viewed as knowledge of devices or systems. Conceptual knowledge relevant to Technology therefore includes '...that drawn from other subjects, such as science, and that unique to Technology'. Procedural knowledge (Technology's syntactical character) is sometimes referred to as explicit, intuitive, or inherent knowledge. In his advice, Ankiewicz (2013c) eludes that design, modeling, problem solving, systems techniques, project planning, quality assurance, and optimization, all need technological procedural expertise. Procedural knowledge, with the exception of conceptual knowledge, cannot be taught in the traditional sense. The epistemology and methodology of Technology conclude that it is critical to guarantee that both conceptual and procedural knowledge are covered in Technology curricula. If the Technology curriculum begins with procedural knowledge, which is gained primarily through practice, and the Technology that is to be presented as a phenomenon is to be ontologically justified, it must be contextualized by incorporating conceptual knowledge, the main themes of which are structures, control systems, and material processing. Technology curricula should contain procedural knowledge on how to design and make such artefacts, as well as conceptual knowledge of Technology as artefacts, it is the presence of conceptual knowledge that enables the successful application of procedural problem-solving knowledge. The relevance of the interplay between technological knowledge and procedural knowledge grows as the complexity of devices grows. As a result, technical procedural knowledge should be included in technology curriculum in such a way that learners have enough opportunity to practice.

For Ankiewicz (2013c), the Technology curricula cannot solely include conceptual knowledge of Technology as artefacts; they must also

When developing future short-learning programs for Technology teachers' continuous professional development, both conceptual knowledge ("knowing that") and procedural knowledge ("knowing how") should be given equal consideration. I agree with Ankiewicz (2013c) that the mutually beneficial and interwoven nature of both conceptual and procedural knowledge, for Technology Education pedagogy, are necessary to inculcate appropriate theoretical knowledge and practical skills.

	include procedural knowledge of how to design and make such artefacts, and vice versa: '...it is the possession of conceptual knowledge that enables the effective use of procedural knowledge of problem solving.'	
Methodology	Ankiewicz also states that the third mode in which Technology is manifested, is Technology as activity: for him, Technology includes more than material objects such as tools and machines and mental knowledge or cognition of the kind found in engineering sciences despite the quickness with which people think of physical objects when 'Technology' is mentioned ... activity is arguably its primary manifestation. Technology as activity is that pivotal event in which knowledge and volition unite to bring artefacts into existence or to use them; it is likewise the occasion for artefacts themselves to influence the mind and will' of the user. Epistemology usually includes methodology, which focuses on procedural experience in the discipline of Technology. The object of study in design methodology is design processes. Which should be at the center of all pedagogic practices for Technology. The two different paradigms, namely the rational problem-solving and the reflective practice paradigm form the basis of design methodology. Advanced cognitive processes underlie and are a component of technological activities. Technology can therefore be considered as both 'minds-on' and 'hands-on' . According to Ankiewicz , two radically different paradigms form the basis of the discipline of design methodology: • The rational problem-solving paradigm, where 'objective' observation and logical analysis lead to general, formal design models and pave the way for objective interpretation – the structured approach generally associated with engineering. • The reflective practice paradigm, which shifts the focus from general design models to the uniqueness of every design problem, where reflective communication with the situation takes place and there is room for subjective interpretation – a less structured approach usually associated with architecture. During the design process, there are three phases: I the conceptual phase, the information phase, and the embodiment phase. The rational problem-solving paradigm may be easily linked to all three phases, but the reflective paradigm is only applicable to the conceptual phase.	Developers may consider emphasizing the use of the design process while designing future short-learning programs for Technology teachers' continual professional development. This may be accomplished by taking into account the three work kinds that are appropriate for Technology Education (see section 2.6.7 below)

	The reflective practice paradigm better describes the conceptual phase of the design process since it is a more subjective design activity. Most design activities during the information phase of such a design project require objective interpretation and are thus best characterized by the rational problem-solving paradigm. Technological know-how entails cognitive resources,' as previously said, and that sophisticated cognitive processes are part of technological activity. Some of these cognitive processes also form the foundation of features such as creativity and entrepreneurial attitude and conduct linked with Technology as volition. Most technical process models depict a linear progression, presuming that the process is finished in a specific order .Learners must use some of the sub-processes of complex thinking at each level of the technological process. The danger inherent in these stage-oriented models is that learners follow it like a ritual exhibiting a veneer of accomplishment while actually following their own process of design or are totally unaware that there is a process to be learnt. From a methodological standpoint, it is evident that the development of thinking and cognitive capacity should be prioritized in the Technology curriculum. It has also become evident that the conceptual phase of a design project may be better defined by reflective design, and learners should be given chances for reflective design as well. It is therefore recognizable that in the Technology curriculum, the development of thinking and cognitive ability should be stressed. According to Ankiewicz (2013c), the conundrum for Technology Curriculum designers is how to make apparent the implicit procedural knowledge on which Indigenous Technological Knowledge Systems are strongly reliant on, within the Curriculum.	
Volition	Ankiewicz concludes that the fourth mode in which Technology is manifested is Technology as volition, which is the most complex manifestation to grasp. The consequence of the practitioner's will is technology as volition. Volitional processes, urges, ambition, aspiration, plans, and choice are all linked to Technology. For Ankiewicz (2013c), considering Technology as volition necessitates an ethical examination of the Technology. It will be important to address ethical elements of Technology and its volitional features, as well as Technology as volition. Furthermore, referring to Technology's volitional qualities, such as drive,	When creating future short-learning programmes for Technology teachers' ongoing professional development, it's important to remember that problem solving is at the heart of the specific learning outcomes of the short-learning programme. People are usually driven to discover answers to issues by their desires and needs. Participants in the short learning programme should be inspired and motivated to embrace different ways to address the problems that are presented to them. This in my view, is necessary for the

	impact, conscious choice, and free will, rather than claiming that it expresses itself as volitional behavior, is more accurate. However, because Technology has a human origin, it is critical not to include Technology as volition in isolation in the curriculum, but rather to combine it with the previously described manifestations of Technology. It should not be overlooked that man is the one who holds specific technological conceptual and procedural knowledge, which he must extend and improve. Regarding the extent to which the CAPS for Technology in the senior phase is aligned with the aforementioned curriculum evaluation criteria, it is important to note that this evaluation is limited to the extent to which the CAPS is aligned with the criteria, rather than reaching a major assessment of the CAPS' significance and efficiency (Ankiewicz, 2013c). According to Ankiewicz (2013c), the struggle for survival and self-development motivates indigenous cultures' everyday technological efforts (social/humanistic aspects). The ontology, epistemology, and methodology of technology must all be included into the Curriculum.	development of problem solving and cooperative learning skills (see Section 2.3.2.5, Section 2.3.2.6 and Section 4), while fostering SDL abilities.
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According to Ankiewicz's (2013c, 319), "these four modes are directives for Technology classroom pedagogy (Ankiewicz, 2013a), Technology teacher education (Ankiewicz, 2013b), and for Science, Technology and Society (STS) studies (Ankiewicz, De Swardt & De Vries, 2006). The philosophy of Technology, therefore, establishes the philosophical foundations for Technology as a field of human endeavor (Ankiewicz, 2013c, p. 320). "Technology Education has Technology (as that which is or exists) as discernible entity and takes place when educators teach Technology to learners. Technology as a subject, on the other hand, refers to its inclusion as a component of the school curriculum" (Ankiewicz, 2013b, p. 320).

2.3.2.5 Self-directed learning

There has been a considerable interest in for consideration of self-directed learning in Education (De Beer & Gravett, 2016). This might be attributed to the advantages which can be achieved should both teachers and learners can be self-directed in Technology Education. As reported by Seleke et al., (2019, p. 364), "according to Knowles (1975), "the process of self-directed learning consists of individuals who take initiative for their learning activities, diagnose their learning needs and formulate learning goals, identify relevant resources for learning, select suitable learning strategies, and evaluate learning outcomes". De Beer (2016, p. 47) acknowledged about eight features that guides self-directed learning as "openness to learning opportunities, self-reliance as a learner, initiative and independence in learning, informed acceptance of responsibility for own learning, love for learning, creativity, focusing on the future, and the ability to utilise problem-based learning approaches". It is on this note that one aspect of the SLP in technology emphasized problem solving. By its nature, Technology Education in the Senior Phase requires that learners should engage with problems from which solutions needs to be sought. I agree with Savery (2015, p. 8), that "the development of self-directed learning, when employing PBL as a teaching and learning strategy", is an important component that fosters life-long learning.

In the current research, Technology teachers worked together in an SLP to solve the identified problem and developed indigenous technological artefacts as outlined in the given scenario (see section 3.3.3). By applying the steps of problem-based learning, the participants also demonstrated attributes of SDL.

2.3.2.6 Problem-based learning and cooperative learning approaches for Technology Education

PBL is a pedagogical strategy and driver of learner-centered activities where learners identify specific needs, formalize goals, do relevant research and develop solutions to a problem (Seleke, Havenga, et al., 2019). As already outlined in 2.3.2.5 above, “the short learning programme (SLP) was developed to provide opportunities for acquiring indigenous knowledge, skills and practices where Technology teachers collaborated to address a real-world problem and share their experiences” (Seleke, Havenga, et al., 2019, p. 363). The SLP affords prospects for expounding on knowledge and skills in a specific field of training concluded over limited period of time (Seleke, Els, & De Beer, 2019; Seleke, Havenga, et al., 2019; Seleke, Speight Vaughn, & De Beer, 2018). Globally, teachers work in different communities that require the inclusion of teaching methodologies to accommodate diverse learners in their classrooms (Gumbo, 2016, 2017; Seleke, Els, et al., 2019). It is for this reason that problem-based learning strategies can be used in Technology Education because, it “provides for subject-specific discourse, innovation and synergistic development of solutions to a problem” (Seleke, Havenga, et al., 2019, p. 363).

Furthermore, Seleke, Havenga, et al (2019, p. 363), elude that “in this context, during the delivery of the SLP, the problem-based activities start with a driving question or challenge to be addressed”. It is interesting to note that both problem- and project-based learning comprises of aspects of the other and thus both has provision for team cooperation, critical argumentation and decision making to address a problem in the best interest of the team (Seleke, Havenga, et al., 2019). As a result, group members improve on their essential critical problem-solving skills that might be necessary in the future, as they learn from past and present experiences. Although PBL is used as a learner- centered approach in the Technology Education pedagogy, teachers need to be actively involved in the detailed planning, facilitation and sequencing of teaching and learning activities that learners need to apply in a problem context (Seleke, Els, et al., 2019; Seleke, Havenga, et al., 2019; Seleke et al., 2018). It is for this reason that it is vital that Technology Education teachers should select suitable ill-defined problem or challenge, supports learners and necessitates regular feedback. A closing discussion should follow on “...what concepts and principles have been learned” (Savery, 2015, p. 9).

Teaching in Technology Education requires various interventions from teachers to ensure the successful understanding of the content by learners. Cooperative learning strategy as a teaching strategy holds a novel opportunity for Technology Education teachers to adopt in order to ensure that learners work together in solving problems that they face on daily basis in technology classrooms. According to Singh (2011, p. 1), Cooperative learning may be

defined as “the learning process in which individuals learn in a small group with the help of each other”. This form of teaching strategy put more emphasizes collaboration amongst teachers and learners whereby teachers infuses this method to make learning process much easy for learner. Other studies have defined cooperative learning as the instruction strategy where students work together to achieve a learning target (Abrami, Poulsen, & Chambers, 2004). Furthermore, it is suggested that cooperative learning improves motivation, class participation and achievements of students (Polloway, Patton, & Serna, 2001). Cooperative learning ensures that there is interaction between the teachers and learners which then under the guidance of teachers it extends to the successful interaction between students amongst themselves Kessler, (1992). Johnson and Johnson (2019) identified five essential elements for cooperative learning, namely positive interdependence, individual accountability, face-to-face promotive interaction, interpersonal and small-group skills, and group processing.

Cooperative learning as a strategy has various characteristics that are infused together for the success implementation of this method in schools by teachers. Different studies conducted by Slavin (2013; 1995, 2010; 2011) have indicated that the cooperative learning strategy has four various perspectives which are; motivationalist, social cohesion, cognitive development and cognitive – elaboration as the major role players in the achievement of this learning method. This strategy helps teachers and learners to build a relationship in the teaching – learning process whereby learners are much involved in the process of understanding content of the subject. Richards (1990), postulates that a classroom is a setting where teachers and students' behavior is managed through daily interactions during lessons. Similarly, Mayer (2013) adds that the classroom provides an ideal setting for students to express attitudes that help them engage in the learning process.

2.4 Indigenous Knowledge Systems and Indigenous Technologies

Emeagwali (2014, p. 1) defines *Indigenous Knowledge* as: “the cumulative body of strategies, practices, techniques, tools, intellectual resources, explanations, beliefs, and values accumulated over time in a particular locality, without the interference and impositions of external hegemonic forces”. Gandile, Tessema and Nake (2017) elaborate that indigenous knowledge, which includes local knowledge, traditional knowledge, cultural knowledge, indigenous health knowledge, as well as indigenous technological knowledge, is knowledge that is culturally transferred over generations and time. In my research, I emphasise the “locus of indigenous knowledge’ as inherently situated in genealogy as a cultural repository where such knowledge is connected, transferred, and extended from one generation to the next” (Seleke, Havenga, et al., 2019, p. 363).



Figure 2.1: Ester Mahlangu doing Ndebele culture house paintings. The vibrant symbols and expressions portray communications of personal prayers, self-identification, values, emotions, and marriage. Copy of the original photograph taken by Lubabalo, D, reproduced under the Creative Commons Attribution-Share Alike 4.0 International license (<https://creativecommons.org/licenses/by-sa/4.0/>)

For Seleke, Havenga, et al (2019, p. 363), “South Africa as a diverse nation, has a rich treasure-house of indigenous knowledge, practices and traditions which inform how each community solve particular problems”. Osaki (1994) lists the following categories of indigenous knowledge: (i) traditional herbal healing, (ii) traditional midwifery, sex, prediction of babies, (iii) treatment of animal diseases, (iv) crafts, including carving various goods, e.g. beehives, mugs, and stools, (v) clay pottery, (vi) water treatment through ashes, boiling, cooling and filtering, (vii) Food processing, preservation and storage, (viii) animal husbandry, e.g. castration and dehorning, (ix) making traditional make-up, (x) making soda ash for cooking and tobacco mix, and (xi) brewing and malting.



Figure 2.2: Sefalana – a Batswana indigenous storage granary made of grass, cow dung and clay, used to store food in. Copy of the original photograph taken by Vincent Rapoo at the Phuthadikabo Museum in Botswana. Reproduced under the Creative Commons Attribution-Share Alike 3.0 Unported license (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>)

Indigenous Knowledge is shared amongst members of a community by means oral narratives, participation in ordinary activities and rituals, including story-telling, practical demonstrations, recreation and sport activities, proverbs, metaphors and analogies, tales, recitations, poetry, riddles, songs, praise songs, puzzles, music, arts and crafts,, dance, drumming, tongue twisters, word games, reasoning and debate, pottery, food preparation and preservation, beadwork, different ways of house constructing, and other forms of cultural activities and expressions (Gumbo, 2017; Gumbo, 2020).



Figure 2.3: Exhibition of the interior living space of an *iQhugwane* (Nguni beehive hut) at the Mtonjaneni Zulu Historical Museum in Northern KwaZulu-Natal. Two *iziGqiki* (singular: *isiGqiki*, wooden head rest) serving as *imiQamelo* (singular: *umQamelo*, pillow) are visible on two *amaCansi* (sleeping mats, singular: *iCansi*), often made of *iNcume* (a rush species). Between the mats is an *iVovo* (beer filter) placed in an oval-shaped *iThunga* (milk pail, plural: *amaThunga*) behind the rounded *uKhamba* (beer pot). On the right a Zulu man's loin and buttock coverings (*isiNene* & *iBeshu*) hang from a wooden frame. Tradition dictates that the woman would sleep on the man's right, i.e. the left side of the photo, and the man may place an invite stick outside the entrance, when she is welcome to enter. Copy of the original photograph taken by JMK, reproduced under the Creative Commons Attribution-Share Alike 3.0 Unported license (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>)

Technology Education Curriculum for South-African schools puts a very strong emphasis on the inclusion of Indigenous Knowledge (Seleke, Els, et al., 2019; Seleke, Havenga, et al., 2019; Seleke et al., 2018). Technology Education permits for the expansion of invention and critical thinking as learners have to make decisions, solve real-world problems and apply appropriate practical skills (Seleke, Havenga, et al., 2019). I concur with the views expounded by Seleke, Havenga, et al (2019, p. 363) that “indigenous technological knowledge denotes a distinctive form of local knowledge since it involves actions and processes, and includes the development of technological artefacts as encapsulated in societies, culture and heritage”. Gumbo (2015, p. 61) claims that technology is “inherently cultural” as the design and development of artefacts reflect cultural beliefs. He elaborates on an integrated view (western

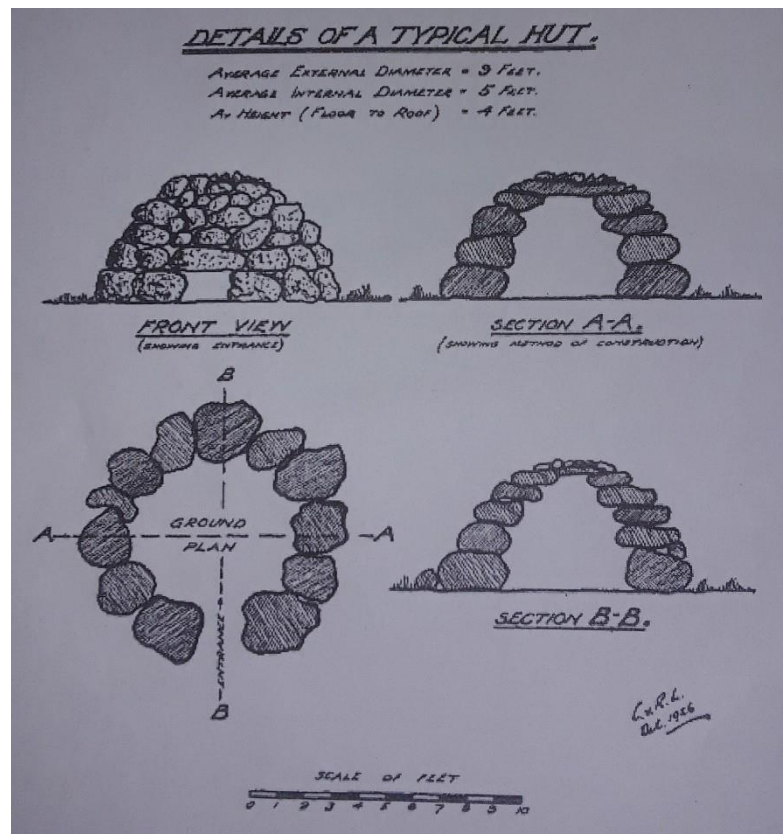
and indigenous) of Technology Education, comprising five main issues (Gumbo, 2015, p. 70):

- “Development of a learner with an “open-mind” who can responsibly apply relevant technologies in a particular local context;
- Technological content knowledge should embrace values, designs, materials and applications with the aim to enrich people’s lives;
- Learning support materials need to include the incorporation of textbooks, relevant resources, and “techno-labs” for the understanding and manufacturing of artefacts that are related to both the western and indigenous technological worlds;
- Pedagogical approaches should be “invitational” to all learners, where they actively engage with community members and the elders regarding the design and development of products;
- Assessment should be “context sensitive” and assist learners to be skillful and professional in their field of study” (Gumbo, 2015, p. 70).

Likewise, Gumbo (2015, p. 70) “highlights the challenges of teachers in indigenous technology as follow: they need to accommodate all learners, regardless of their cultural contexts, as learners enrich teaching and learning activities with cultural nuances” cited in (Seleke, Havenga, et al., 2019, p. 364). Furthermore, “indigenous teachers” should guide their colleagues, and they need to relate with the public at the schools community from which they serve in order to gain wisdom from the elders (Seleke, Havenga, et al., 2019). Teachers and learners should be involve in technological activities in their classrooms while taking into account their cultural perspective while developing applicable solutions to their problems (Seleke, Els, et al., 2019; Seleke, Havenga, et al., 2019; Seleke et al., 2018). It is in this context that, “I accordingly developed a short learning programme for Technology teachers at our higher education institution in South Africa, in order to explore the infusion of Indigenous Knowledge in Technology according to the steps of problem-based learning (PBL), an SLP at a higher education institution in South Africa was developed for teachers” (Seleke, Havenga, et al., 2019, p. 364).

Stone Corbelled (Bee-hive) Houses of the Leghoya

The Leghoya (Bataung – “People of the Lion”) was one of the first Bantu people to cross the Vaal river and settle in what is today known as the Orange Free State. Ruins of their corbelled (bee-hive shape) stone houses can still be found on the flat hilltops bordering the Valsch, Rhenoster, Wilge, Sand and Mooi rivers.



Symbiotic Relationship with Nature

Like the other Batswana people, the Leghoya people were great cultivators of millet, which took eight months to bring to full perfection. However, as soon as the millet was planted into the ground, it was under constant danger of being eaten by destructive insects like worms and caterpillars. The Leghoya ingeniously called in the assistance of industrious little creatures to combat such insects. The Leghoya bruised and buried bones in their plantations, in order to attract ants to their fields of millet. These ants would then attack and kill other insects like worms and caterpillars entering the plantations, thereby saving the Leghoya’s millet harvest from being destroyed.

Figure 2.4: Indigenous Knowledge and technologies of the Leghoya people derived from Walton (1965, p. 27). Drawing of a typical Leghoya hut taken from Walton (1965). Copy of the original photograph of Millet taken by Kurt Stüber, reproduced under a GNU Free Documentation License (<http://www.biolib.de/mavica/fdl.txt>)

2.4.1 Andragogical and pedagogical infusion of Indigenous Knowledge and indigenous technologies into Technology Education

Technology Education encourages the development of innovation and critical thinking skills, as learners have to make decisions, solve real-world problems and apply appropriate practical skills. Moreover, it requires from learners to understand and apply technological knowledge and cultivate various views on technology in society (Department of Basic Education, 2011). Indigenous technological knowledge denotes a distinctive form of local knowledge, since it involves actions and processes, and includes the development of technological artefacts, as encapsulated in different societies, cultures and forms of heritage (Havenga, 2019).

Indigenous Knowledge and technologies are pedagogically relevant and easily applicable to Technology Education, due to its' practical, cultural and social nature (Gumbo, 2014, 2015, 2016; Gumbo, 2019). According to Gumbo (2015, p. 70), the following are essential features of indigenous Technology teachers: "(i) they need to accommodate all learners, regardless of their cultural contexts, as learners enrich teaching and learning activities with cultural nuances; (ii) indigenous teachers should mentor their peers, and they need to interact with the community to gain wisdom from the elders; (iii) indigenous teachers and learners should engage in technological activities, which recognizes diverse cultural and social contexts, in order to find solutions for community-based problems".

2.4.2 Existing frameworks for the infusion of Indigenous Knowledge into Technology Education

Literature postulate quite a number of frameworks ideal for infusing Indigenous Knowledge in Technology Education. I especially took cognizance of two existing frameworks, i.e. (i) Gumbo's (2018) adaptation of Seemann's (2000) Technacy Framework for Technology Education, and (ii) the Cultural Responsive Teaching Theory Framework, first proposed by King, Artiles and Kozleski (2009), and later adapted by Gumbo (2018).

2.4.2.1 Gumbo's (2018) adaptation of Seemann's (2000) Technacy Framework for Technology Education

Table 2.6 presents the Technacy Framework for Technology Education, first proposed by Seemann (2000), and later adapted by Gumbo (2018).

Table 2.5: Gumbo's (2018) adaptation of Seemann's (2000) Technacy Framework

Seemann's (2000) Technacy Framework	Application	Sources of examples
Central goal	To develop and produce a skilled and holistic thinking student who can select, evaluate, transform, and use appropriate technologies responsive to local contexts and human needs	Making children's toys whose designs resemble local culture; student investigates local cultural images first which inform his/her designs
Technological content knowledge	Relates to or is packaged from technologies which exist locally and which can sustain lives of people Consider the following strands: - Indigenous definition of technology first before global perspective - Epistemological issues about concept of technology - Local cultural values underlying technology and designs - Evidence of existing technologies and designs in local contexts including case studies - Technological resources and materials available in local indigenous context - Principles of technological applications in local indigenous contexts - Profile prominent local designers and innovators - Trade value of technologies in local indigenous context	Technologies of processing sour milk, hut making, baking bread, hunting, ploughing, slaughtering a cow, dress making, etc. For definitions refer to: Senanayake (2006); Seemann (2000, 2009); Obikeze (2011); and Ogunbure (2014). Ways of technological knowledge generation and how; who are fountains of this knowledge? What are sources of this knowledge? Types of knowledge, etc. Botho (ubuntu), holism, spirituality, value wisdom of elders, etc. (Gumbo, 2016c). Case studies, e.g., house construction (design, structure, materials, etc.) Human (elders/local experts), physical (wood, stones, animal leather, etc.) Observation, group approach, experiential, demonstration, etc. (Gumbo, 2015). David Adjaye, Francis Kéré, Mokena Makeke, Mpheti Morojele, etc. Ceramic products, textile materials, art of all sorts
Learning support materials and equipment	Local learning support materials and equipment which students can better identify with: - Textbooks and other resources - Examples and student activities - TE classroom/lab equipment	Indigenous authors and artefacts Engage with elders on local technologies, identify local engineers, architects, identify local problems, and design relevant sustainable solutions using locally available resources, etc. Indigenous designs and manufacturing; open labs, i.e., learning and doing practical activities in an open – engaging technological experts in communities
Pedagogical approaches	Varied pedagogical strategies: - Critical epistemological discourses about technology - Curriculum content - Adopt the community model of coteaching student with local technologists (especially elders) - Learning activities (social cohesion, development, and sustainability) - Flexible approach	Culture and technology, values issues in technology, intangible technologies, etc. Local symbols and content – Great Zimbabwe ruins, Mapungubwe, iron smelting, brick making, etc. Group design projects that engage community members for guidance Alternative ways such as emergent designs rather than follow design process blindly Orality, storytelling, demonstration by elders and/or experts, gamification, simulation, singing, etc.
Assessment	A planned-in assessment (pre-planned and integrated in the learning activities):	Based on content and experiences which students can identify with rather than on rote learning

Seemann's Technacy Framework	Application	Sources of examples
	- Strictly related to learning materials and content - Targets applied knowledge and is context based - Helps to graduate student who masters local technologies - Relevant to student's personal domains	Enrich assessment with holistic experiences Interest in local technologies such as transport modes so student can respond relevantly to local technological needs Balance academic assessment with physical, emotional, and spiritual forms; shift from zone of cognitive competence to zone of trustful intuition

2.4.2.2 Gumbo's (2018) adaptation of the Cultural Responsive Teaching Theory Framework proposed by King, Artiles and Kozleski (2009)

For the purpose of this qualitative case study, I applied the culturally responsive teaching theory as one of the lower-order constructs of my conceptual research framework (see Chapter 1, Section 1.4.1). In Chapter 1, Figure 1.3, I applied the framework first proposed by King, Artiles and Kozleski (2009), and later adapted by Gumbo (2018), to the unique context of my case study, in order to develop a Higher Education short learning programme for the continuous professional development of senior phase Technology teachers, which provided andragogical opportunities for participating teachers to integrate and use their culturally accumulated Indigenous Knowledge and skills, together with their design process skills in Technology Education, to collaboratively solve community problems by designing and constructing indigenous technological artefacts for given scenarios. According to Szu-Yin and Shernaz (2014), culturally responsive teachers should be able to reflect on their own teaching practices, and should have the knowledge and skills to employ different culturally responsive methodologies, in order to become responsive to the diverse needs of learners in their inclusive classrooms. Culturally responsive teaching also demands from teachers to re-organize their classrooms in order to become accommodative towards the diverse cultural and linguistic needs of learners, and to align their classroom contexts with the contexts of their communities (Mahlangu & Mafuwane, 2015; Szu-Yin & Shernaz, 2014). As diversity influences the way in which teaching and learning manifest in classrooms (Mahlangu & Mafuwane, 2015), Technology teachers should become aware of the diverse needs and expectations of learners, in order to align their teaching practices so that they become relevant to the diverse contexts of their learners. According to Gay (2002), culturally responsive teachers make use of different pedagogical approaches so that their teaching becomes relevant to their learners' diverse cultural backgrounds, as meaningful learning is attainable when the social and cultural background of student are taken into account (Gwekwerere 2016).

2.5. Barriers against the infusion of Indigenous Knowledge into Technology Education

This section examines various barriers/challenges that restrict the effective infusion of Indigenous Knowledge into Technology Education.

2.5.1. *Lack of real commitment towards the integration of Indigenous Knowledge and technologies in the Curriculum and Assessment Statement for Senior Phase Technology Education*

The third aim of the *Curriculum and Assessment Policy Statement for Grades 7-9 Technology* advocates that:

“Wherever possible, learners should be made aware of different coexisting knowledge systems. They should learn how indigenous cultures have used specific materials and processes to satisfy needs, and become aware of indigenous intellectual property rights” (Department of Basic Education, 2011, pp. 7-8).

Although this Curriculum statement promotes awareness of, and indirectly hints towards the possible integration and use of Indigenous Knowledge and technologies into Technology Education, it is justly criticised by Gumbo (2017) for opening with the phrase “*Where possible...*” which does not actually convey a message of real commitment towards the integration of indigenous technology. The repercussion of the Curriculum Policy’s lack of commitment, with regard to the integration and use of Indigenous Knowledge and indigenous technology, is that almost all educational training, workshops and programmes that deliver continuous TPD, are also lacking in the same commitment. Gumbo (2017, p. 155) also points out that the inclusion of the phrases “made aware” and “become aware” in the Curriculum statement, really alludes to no integration of indigenous technologies, while the phrase “have used” furthermore suggests that Indigenous Knowledge is something extinct from a past history.

Indigenous communities globally are in a continuous struggle to preserve their knowledge and privileged as they are in constant contestation with a system conquered by western world views (Magni, 2016). This as posited by Magni (2016) present a challenge for this community for “living in two worlds, the indigenous and the non-indigenous one, in constant tension with each other, with the latter having more power in shaping the former western science and Indigenous Knowledge are represented as two distinct, competing systems of knowledge, characterized by a binary divide, divided from the epistemological foundations of the two knowledge systems (Briggs, 2005). Indigenous Knowledge is viewed by Aikenhead and Masakata (2007) as local customs of people in their natural surroundings which are interconnected and cultured in the verbalized manner by elders in the community which is passed on generation to generation

through demonstrations, storytelling, songs, narrating devotions, celebratory dances, and partaking in divine observances. Even though the notion of Indigenous Knowledge has gained popularity in recent years, its exhibition can be drawn from the existence of human kind on earth (Horsthemke, 2016). For Hoppers (2005, p. 2), Indigenous Knowledge refers to "a total of knowledge and practices, whether explicit or implicit, used in the management of socio-economic, ecological and spiritual facets of life, stored in collective memory and orally communicated through stories, myths, songs, etc. among community members and future generations." However, efforts to understand Indigenous Knowledge are challenged by a number of issues ranging from vagueness of expressions, incomprehensible powers that act on origin of concepts and practises embodying indigenous peoples, collective and traditional living and absence of contextual awareness by teachers to recognise significant or non-significant organisation of learning in the process of preparation and tutoring that supports the infusion of Indigenous Knowledge (Phiri, 2008). As argued by Akpomvie (2011) prior to the colonial rule in Africa, Africans had their own indigenous way of solving their problems including technological inventions done in ivory, wood, the iron, medicine, and cloth weaving. While Indigenous Knowledge structures are diverse from one society to another, the objectives of these structures remained often similar in a manner that they are understood as education for life through which children are brought up (Sifuna, 2008).

Indigenous Knowledge Curriculum studies constitute epistemological issues pertaining to the consumption and production of knowledge and the learning and contestation of all facets of knowledge production and the considerations of education itself. (Semali & Maretzki, 2004). Indigenous Knowledge has become an important component of this idea because it makes it possible to increase the practical value and adaptation of technology to local conditions, preserve highly valued local knowledge and use local skills in constant monitoring and early warning systems and highlights human needs and resources (Magni, 2016).

2.5.2. Lack of appropriate teaching strategies by teachers to infuse Indigenous Knowledge in the Technology Education Curriculum

For IK to be successfully infused, teachers must be able to employ appropriate teaching strategies in the technology classroom that would ensure meaningful learning. Adopting a similar position is Owusu-Mensah (2015), who posit that Indigenous Knowledge must be integrated into the school Curriculum in order to make teaching and learning real and understandable for learners. I believe that teachers are strategically positioned within in the school context to adapt their strategies to infuse Indigenous Knowledge in their classrooms. Likewise, Kistner, Rakoczy, Otto, Klieme and Büttner (2015) holds the view that key aspect of

the consistently claimed promotion of self - regulated learning in classrooms is teaching learning strategies. The non-adoption of appropriate teaching strategies by Technology teachers might be attributed to them not receiving adequate training or perhaps as articulated on the introductory background that not qualified at all to teach the subject. In the 2014 study by Mapotse, the South African Ministry of Education confirmed that while South African school educators are qualified to teach a variety of subjects, many technology educators are uncomfortable with technology pedagogy (Mapotse, 2014). Though the focus of their study was on science teacher, Cronje, De Beer and Ankiewicz (2015), also discovered that many educators definitely struggle in their classrooms to better integrate indigenous knowledge. Furthermore Cronje et al. (2015) adds that this might be attributed to also a lack of expertise regarding teaching methodologies and pedagogical content. I concur with the finding of Jautse, Thambe, and de Beer (2016) who contend that educators do not really inherently have the expert knowledge to deal sufficiently with indigenous knowledge. Another interesting factor is that as posited by de Beer and Petersen (2016) who affirms that during their initial teacher training, teachers were not exposed to Indigenous Knowledge (and did not focus on in-service teacher education as well), as a result of this, teachers then find it difficult to infuse Indigenous Knowledge in their classes. What remains a perturbing factor is the 2014 study by Mapotse, who postulates that 99% of teachers are not suitably qualified to teach technology (Mapotse, 2014). Most of these teachers were only taken to a one-day crash courses then they are expected to sufficiently teach Technology in a manner that integrates the theory and practice as required by subjects.

Mapotse (2014) further articulates that the difficulties facing Technology teachers can be divided into two areas: internal and external factors. For Mapotse (2014), the external factors include (i.e. 8% weekly allocation of time, resources, teacher movement in and out of TE and district planning), while the internal factors are associated to teachers themselves which are (i.e. qualification, inventiveness to effectively deal with limited resources, systems, and control, and teaching, evaluation, and reporting practices, particularly through design processes, and the integration of core technology themes into tasks (Mapotse, 2014). These challenges as further added by Mapotse, can also be understood in South Africa in relation to the party-political transformation from the apartheid education structure to the current one, which has fashioned the current teacher training and development, (Mapotse, 2014).

2.5.3. Lack of Pedagogical Content knowledge by teachers to infuse Indigenous Knowledge in the Technology Education Curriculum

The other factor derailing the infusion of Indigenous Knowledge in Technology classes is their lack of Pedagogical Content Knowledge (PCK). I concur with the definition of PCK provided by

Hashweh (2005, p. 277), who maintains that “Pedagogical content knowledge is the set or repertoire of private and personal content specific general event-based as well as story-based pedagogical constructions that the experienced teacher has developed as a result of repeated planning and teaching of, and reflection on the teaching of, the most regularly taught topics”. Teachers are very important component in the classroom for facilitation and mediation of meaningful learning to their learners. For this goal to be achieved teachers need to have required PCK for the subject that they teach. Notably if they do not have such, their confidence and command of the subject matter shall be compromised, thus certain aspect such as Indigenous Knowledge shall be avoided. The study by Mudalay and Ismail (2013), highlights that most teachers struggle to infuse IK in their classes because they lack the applicable knowledge and skills. I argue that if teachers do not hold any appropriate PCK they might feel uncomfortable with the infusing of IK in their classroom. Pedagogical Knowledge Content (PCK) plays a pivotal part in instruction in the classroom. It is quite encouraging to note a similar position held by Kathirveloo, Puteh and Matematik (2014) who articulate that PCK involves the competence of teachers in delivering the abstract method, socially considerate, and adaptive cognition of the subject matter pedagogy. PCK is regarded as the knowledge and skills employed by the teacher to transform subject Curriculum content into more comprehensible forms for students (Park & Oliver, 2007). Hence effective teaching should start with a clear understanding of what to learn, what to teach and how to teach it. Technology is a learning area that needs qualified teachers because of its nature, especially as a subject based on theory and practice (Mapotse, 2014). Jackson, de Beer and White (2016) affirm that it is therefore crucial that teachers develop their knowledge of pedagogical content to understand and teach indigenous knowledge, creating a more nuanced view of the nature and resources of indigenous knowledge. There is some consensus amongst Indigenous Knowledge scholars that teachers therefore need to have knowledge and understanding of the subject matter to be taught, the hindrances that learners are likely to face, and the apt methods and plans that can be used to offer content to learners in an efficient manner (Gumbo, 2016; Jackson et al., 2016; Jacobs, de Beer, & Petersen, 2016). Reddy, Ankiewicz, De Swardt, and Gross (2003), suggest that Technology teachers need to find suitable approaches that will assist them to teach the subject matter content efficiently and to develop appropriate skills and methods that give their learners the liberty to think and decide. PCK is therefore pivotal component for teachers to be able to transmit their personal knowledge in a manner that makes sense to their students.

2.5.4. Lack of understanding about the cultural diversity of learners by Teachers to infuse Indigenous Knowledge in Technology Education Curriculum

Cultural diversity may be defined as the “coexistence of numerous distinct ethnic, racial, religious, or cultural groups within one social unit, organization, or population” (Morris, 1982, p. 955). According to Pareja & López (2019), given the increase in cultural and ethnic diversity in the classroom, educators are faced with the challenge of to interact confidently students who differ in culture and ethnicity (Burden Jr, Hodge, & Harrison Jr, 2012). In South Africa, with its diverse society, reconciliation and changes in system of education and educational landscape (e.g., schools, universities) brought major challenges to educators, such as increasing the student population's heterogeneity, changing curricula and establishing a new educational legislature (Meier & Hartell, 2009). Prior to the new dispensation most teachers were comfortable in working in homogenous cultures as was designated by the then regime. The dawn of democracy then disintegrated the artificial cultural barriers that previously existed. Consequently, schools have now also changed from a one cultural context to a diverse cultural context, resulting in the majority of South African teachers located increasingly in classrooms environments full of learners from diverse cultural backgrounds that differs from theirs (Jacobs, 2015). As a result of this changes, most South African Technology teachers experienced challenges which included having had to teach multicultural classes. I agree with the observation by Jautse et al., (2016) who noted that within the context of a multicultural society in South Africa, teachers may not perfectly understand the cultural practices of other cultural groups other than their own cultural practices (Jautse et al., 2016). This might have resulted in some useful Indigenous Knowledge from other cultural groups being belittled and regarded as not being authentic knowledge. Similarly, teaching in today's culturally diverse classrooms should put their attention on collaborating with all students and negotiating daunting academic content with all students by constructing knowledge on their different cultural practices rather than simply promoting and teaching one or more standard dialects (Garcia & Sylvan 2011). For Indigenous Knowledge to be adequately infused in the technology classroom, Technology teachers need to be able to embrace the diverse cultural background of their students. This would present a novel opportunity for Technology teachers to be able to draw from the wealth of knowledge at their disposal and integrate in meaningfully in their classes. However, teachers may not have the necessary pedagogical knowledge to build on the Indigenous Knowledge of diverse learners in a constructivist manner (Gumbo, 2016). Like Gumbo (2016), Hinojosa Pareja and López (2018) argue that teachers ' discerning and comprehension of cultural diversity are replicated in their activities, planning and assessment, as well as their expectations of their student's educational background. With competent teachers, then schools would be able to offer a conducive environment for their learners to relate in a more diverse and collaborative atmosphere and thus promote social cohesion (Aydin, Ozfidan, & Carothers, 2017). Hence

teacher training institutions have a mandate to equip pre- service teachers adequately so that they are able to accommodate the needs of increasingly more diverse learners in a multicultural society (Sharma, Forlin, Loreman, & Earle, 2006).

2.5.5. Lack of proper interpretation of Curriculum Documents

The introduction of Indigenous Knowledge into the official South African school Curriculum raised a lot of challenges on how in-service teachers interpreted and implemented such a Curriculum (Naidoo & Vithal, 2014). For Curriculum policies to be implemented correctly requires of teachers to understand such policies to ensure that the intended Curriculum objectives are achieved succinctly. Nkosi (2014) reminds us that the South African education system has undergone through several changes in the curricula in an effort to improve and address challenges related to inequality and lack of quality in the education system which was indorsed the previous apartheid dispensation. These changes in Curriculum, presented quite a number of challenges for teachers, which were often taken to one-day crush courses and expected to fully implement the prescribed Curriculum.

Mudaly and Ismail (2013), like Nkosi, maintains that due to the socio-political, and economic impacts that materialised at the dawn of its democratic era, the South African educational landscape has witnessed several changes in Curriculum policy over the past two decades. The continuous Curriculum reviews without suitable interventions to prepare teachers often leaves teachers frustrated even though they are the ones who have the vital tasks of implementing any changes in the Curriculum (Tshiredo, 2013). However, amid these Curriculum changes, teachers were not adequately prepared to amply construe the Curriculum documents. Such challenges, more often than not frustrated teachers, affected their confidence of the subject matter content. Notwithstanding that one of the most important roles of a teacher is to be able to correctly interpret and implement the prescribed Curriculum policies. Makgato (2014), cautions that the concept of a Curriculum is broad and comprehensive in itself, thus allowing it to be interpreted in a variety of ways. Hence the infusion of Indigenous Knowledge was then pushed to the peripheral space, not receiving the attention that it deserves. This leads to teachers interpreting the Curriculum in a variety of ways, partly because of their different perceptions and contexts they find themselves in (Makgato, 2012). This inconsistency has the potential to make teacher disregard the infusing of Indigenous Knowledge into their learning experiences. The professional teacher development opportunities that was meant to assist teachers cope with changes in Curriculum where often inadequate, as teachers always

displayed signs of confusion and struggle to apply proposed changes in their classrooms (Tshiredo, 2013). In the same tone Mapotse, (2014) adds that teachers face the challenges of interpreting, analyzing and implementing technology policy in this regard compromising adequate infusion of IK. Furthermore, there had been a legitimate problem with the misinterpretations of the Technology Curriculum document, work-schedules, and lesson planning and the lack of resources available (Mapotse, 2014; Mapotse & Gumbo, 2020). There are ambiguities and misinterpretations of Technology Education due to the lack of professional development and teacher general awareness of what Technology Education means (Makgato, 2014). In most cases, teachers' roles had changed from being mere transmitters of knowledge to being facilitators of learning content in the manner that enables them to help learners to attain prescribed Curriculum goals which can only happen if they are able to properly interpret prescribed Curriculum documents and the (Tshiredo, 2013). As a result, misinterpretation of Curriculum documents has the potential to make teacher misunderstand the Curriculum goals, leading to teachers facilitating technology lessons in the manner that is no appropriate for the subjects.

2.5.6. Lack of collaboration amongst education stake holders to infuse Indigenous Knowledge in the Technology Education Curriculum

According to Lai (2011) collaboration is the “mutual engagement of participants in a coordinated effort to solve a problem together” (p.2). The broader community of stakeholders, such as parents of children attending schools, needs to be involved in the school Curriculum to successfully infuse indigenous knowledge. This is consistent with the report of the study conducted by Lai (2011) who mentions that co-operative relations are characterized by shared vision, construction evenness, and a high degree of mediation, interactivity, and social relations and interactions able to produce elaborate justifications which are particularly valuable in order to improve student learning .Hence it is pivotal for indigenous communities to take part in the designing of education policies in order to have meaningful and relevant education for indigenous children and young people (Magni, 2016). De Beer and Petersen (2016) points out that the involvement of different education stake holders is the key to the successful implementation of any educational initiatives which I believe infusing of Indigenous Knowledge in Technology Education is one such initiative. The disadvantages of presumed academic disagreement with community involvement motivated the Interinstitutional Consortium for Indigenous Knowledge (ICIK) to take very seriously the issue of engagement (Semali & Maretzki, 2004). It is also very important to note that stakeholder collaboration hold a very noble opportunity to note all knowledge systems as equal partners deserving of epistemological

recognition. Equally important is where all cultures conglomerate with in the epistemic space to enhance the infusion of Indigenous Knowledge in Technology Education and thus foster self-directed learning amongst learners. As posited by (Flor, 2013) the exact same tradition of hierarchy, exclusivity, ritual, and secrecy also guides indigenous belief systems covering knowledge transmission, sharing and reuse which can when the hegemony of one over the other. Further advice is that the conventional and popular culture had often misconstrued Indigenous Knowledge and practices and abused them (Flor, 2013). It is therefore necessary to find space within the epistemic border crossing to equally recognise both the western and indigenous ways of learning for Technology Education which can be addressed adequately by stakeholder collaboration.

2.5.7. Lack of Technology laboratories or workshops

The other hindrance for infusion of Indigenous Knowledge in technology classroom to foster self-directed learning is lack of ordered environment (Technology laboratories). The nature of the subject Technology warrants that learners be able to do theory and practice. To achieve be able to infuse both theory and practice then the learning environment should be conducive. However, the implementation of the Technology Curriculum like in other subjects has been continuously mired by inadequate facilities such as classrooms appropriately equipped laboratories, libraries and appropriate technology workshops (Pool et al., 2013; Potgieter, 2004, 2013; Teis, 2014). The theory and practise nature of technology requires that students to always be exposed to an enabling task by which their designs are designed and made artefacts (Pudi, 2007). In a more orderly environment such as technology laboratories or workshops, this can be achieved more effectively. Through its Curriculum and assessment, the Ministry of Basic Education only talks about designated classrooms as a requirement for technology teaching but does not specify how and the content of such a designated classroom should be. In a study conducted by Mapotse (2014). Technology teachers at nominated schools in the province of Limpopo reported that they did not have an well-arranged classroom environment (workshop or lab) to actually teach, facilitate a conducive learning environment and practice technology (Mapotse, 2014). It is therefore very important to equip schools with workshops and practical laboratories coupled with teachers who have appropriate practical skills including equipment to allow for transfer of appropriate skills and knowledge for the 21st century economy (Mapotse, 2014; Mapotse & Gumbo, 2020). There is a need for deliberate action to be taken to properly equip our schools to support learning. Hence, Makgato, (2014) posit that technology workshops and laboratories need to be suitably equipped and accredited, for that to be achieved then partnership between schools, higher education and industry should be forged.

2.5.8. *Negative attitude of Teachers to infuse Indigenous Knowledge in their classrooms*

The attitude of the teacher towards a subject has the ability to influence how such a subject is facilitated. For Indigenous Knowledge in Technology Education to be consolidated successfully, Technology Education teachers need to have a very positive attitude. However, that is not usually the case as most teachers seem to be uncomfortable with indigenous knowledge, which can be as a result of their cultural background or their religious orientation. I concur with Mapotse (2014), who submits that in order to advance the ability of students in Technology Education, then Technology Education teachers and Technology Education scholars should first have the ability to influence a positive attitude towards the subject including focusing on positively influencing their students to love the subject, identifying students with technology and then augment their desire to learn technology. If the attitude of teachers towards Technology Education is negative, then their facilitation of the subject is going to be negatively affected which also has a bearing on student learning of the subject. In their study, de Villiers, de Beer and Golightly (2016), postulate that the training opportunities offered to Technology Education teachers by the department of basic education are so limited and this has the ability to play a role in teachers' ongoing negative attitudes towards IK and socially constructivist pedagogical strategies. The data reviewed here appears to indicate that a possibly demoralizing big obstacle that leads to the pessimistic mind-set of teachers towards technology teaching is that the majority of Technology teachers have been required to teach this subject without any requisite teaching skills on the subject. As a result, these teachers have followed a 'wait-and-see' approach and expect a systematic approach (Mapotse, 2014; Mapotse & Gumbo, 2020). In view of all that has been mentioned so far in this literature review, one may further assume that the other contributing factor to teachers negative attitudes towards assimilating IK in Technology Education is the observation that Indigenous voices are still silenced and dominated to a large extent, while Western knowledge is continually visible in schools and society (Jacobs, 2015). Furthermore, I concur with Teo (2008), who claims that for any educational programs to succeed, the support and attitude of teachers as drivers of such initiatives, should be taken into account.

2.5.9. *Lack of continuous teacher professional development opportunities*

Most teachers in South Africa were trained are not professional qualified to teach technology as most were recruited from other subjects to teach technology (Teis, 2014). The lack thereof, of suitably qualified Technology teachers has the potential to make teachers avoid those topics that they are not familiar to teach (Pool et al., 2013; Potgieter, 2004, 2013). It is for this reason

that I believe, the shortage of suitably qualified teachers compromise the infusion of Indigenous Knowledge in technology classrooms. Mostly the one day or two day workshops are often only focusing on certain aspect of Curriculum coverage that aimed at preparing learners to pass examinations (Potgieter, 2013). Several scholars (De Beer & van Wyk, 2011; Pool et al., 2013; Pudi, 2007; Teis, 2014) avers that lack of continuous teacher professional development opportunity is a hindrance that restrict the infusion of Indigenous Knowledge into Technology Education.

2.6. Possible solutions/enablers to overcome the barriers restricting the infusion of Indigenous Knowledge and indigenous Technologies into Technology Education

2.6.1 *Existing framework and objectives of the Indigenous Knowledge Systems (IKS) Policy*

In recent years, there has been a worldwide interest on the recognition and preservation of Indigenous Knowledge Systems. A number of countries expressed their commitment towards the educational integration and use of Indigenous Knowledge Systems in the form of policy initiatives aimed towards the system-wide acceptance and preservation of Indigenous Knowledge systems for their respective citizens. South Africa counts amongst these countries that have daubed such policy frameworks. In her submission to the World Intellectual Property Organization, South Africa posits that: *The Indigenous Knowledge Systems (IKS) Policy* by the Department of Science and Technology (2004, p. 4)) “*is an enabling framework to stimulate and strengthen the contribution of Indigenous Knowledge to social and economic development in South Africa. The main IKS Policy drivers in the South African context include:*

- *The affirmation of African cultural values in the face of globalization – a clear imperative given the need to promote a positive African identity.*
- *Practical measures for the development of services provided by IK holders and practitioners, with a particular focus on traditional medicine, but also including areas such as agriculture, indigenous languages and folklore.*
- *Underpinning the contribution of Indigenous Knowledge to the economy – the role of Indigenous Knowledge in employment and wealth creation.*
- *Interfaces with other knowledge systems, for example Indigenous Knowledge is used together with modern biotechnology in the pharmaceutical and other sectors to increase the rate of innovation”.*

In the executive summary of the above policy, the South African Department of Science and Technology (2004, p. 9), proposes several functions, institutions and legislative provisions that will ensure that the policy objectives are realized. The following are proposed:

- “An Advisory Committee on Indigenous Knowledge Systems, reporting to the Minister of Science and Technology.
- A development function; including, academic and applied research, development and innovation in respect of IKS.
- A recordable system for Indigenous Knowledge and Indigenous Knowledge holders, where appropriate, to pro-actively secure their legal rights.
- The promotion of networking structures among practitioners, to be located in the Department of Science and Technology.
- Legislation to protect intellectual property associated with indigenous knowledge, to be administered by the Department of Trade and Industry”.

Further commitments were made for the inclusion of Indigenous Knowledge in the South African school curriculum. Chapter two of the *African Manifesto on Indigenous Knowledge* stipulates the interwoven nature of Indigenous Knowledge systems (Department of Science and Technology, 2006, p. 13). The *White Paper on Education and Training (1995)* states that the essential objective of the education policy is to ensure that all citizens have equal access to quality education in the manner that would ensure lifelong learning to all citizens. The revised White Paper on Arts, Culture, and Heritage, furthermore asserts that culture and education are intertwined, and that the one cannot be separated from the other, hence the need to recognize that cultural norms and practices are conveyed through education (Department of Arts and Culture, 2013). This emphasizes the need to recognize, preserve and infuse Indigenous Knowledge into the Senior Phase Technology Education Curriculum. According to the South African Department of Science and Technology (2004, p.17): *“It is therefore critical to ensure that the national education strategy is synergistic with and nurturing of IK. In the development of the New Curriculum Statements, there has been a strong drive towards recognizing and affirming the critical role of IK, especially with respect to science and Technology Education”*. Technology Education Curriculum offers such a novel opportunity for the infusion of IK as it is more problem based, thus promoting what the policy postulates as an *“approach that is problem solving, and creates further impetus for the central recognition of IK”* (South African Department of Science and Technology, 2004, p. 17). Accordingly, I conceptualised my qualitative case study in order to achieve such a policy imperative for Curriculum conversion in a manner that recognises other forms of knowing, such as indigenous knowledge, and combine it with Western forms of knowing.

2.6.2. Acknowledgement of social identities of learners in the Technology classroom

In the African revival era, educators need to reflect on and use indigenous cultural practices that can enhance learning, as well as project African identity (Owusu-Mensah & Poku 2015). However, too many teachers are unwilling to teach ethnically diverse students (Gay, 2002). By incorporating Indigenous Knowledge into the classroom, it is possible to identify students' social identities, transform learning into a positive experience, and change students' attitudes toward science (Cronje et al., 2015). To give students a sense of pride in their heritage, thus enhancing their interest in the subject and their performance. Teachers are engaged in crossing cultural practices and finding unity within diversity in order to identify cultural similarities and differences (Jautse et al., 2016). Culture is deeply embedded in any teaching; therefore, it is necessary to multiculturalism ethnically diverse students (Gay, 2002). De Beer and Van Wyk (2011) state that research in cognition and neuroscience has resulted in Embodied, Situated and Distributed Cognition (ESDC) becoming popular as a framework. ESDC states that cognitive processes are not just limited to symbolic processing in the brain (Hardy-Vallee & Payette, 2008). A person's activities (exercise and social interaction) affect synaptic strength (Dubinsky, Roehrig, & Varma, 2013). Chahine (2013, p. 434) describes ESDC as "cognition is physiologically embodied, sociocultural situated, and ostensibly distributed among individuals". If a teacher utilize multimodal approaches in the Technology classroom, where learners physically engage with cultural artefacts, such manipulation and social engagement could enhance cognition. Technology teachers should therefore be sensitized towards embodied cognition.

2.6.3. Conceptual change amongst teachers to infuse Indigenous Knowledge in Technology Education

There is a need for teachers to change their attitude regarding the infusion of Indigenous Knowledge in their classrooms. For the success of any Curriculum, teachers need to the perceptions of teachers as Curriculum implementers should be taken into account (Hacker & Barak, 2017). The positive attitude of teachers regarding the apprehension of IK has the potential to influence their ability to develop lessons that included IK based on the pedagogical strategies addressed during the interventions (de Villiers et al., 2016). For de Villiers et al. (2016), a change in the attitudes of teachers regarding both the use of PBL and the infusion of IK into is possible by employing appropriate strategies to assist them be comfortable in their classes.

De Beer and Henning (2013) show that, for conceptual change to occur when dealing with controversial aspects (e.g., indigenous knowledge), teachers first have to *accept* the

phenomenon. These authors refer to the construct of Pintrich, Marx and Boyle (1993) of “hot cognition”, where conceptual change means that conflicting constructs must be incorporated in a person’s schemata or world view. Cobern (2000, p. 570) states that “there is no unambiguous epistemic distinction between knowledge and belief ... For all practical purposes, belief and knowledge both represent what one has reason to believe is true (or valid)”. It is thus important that such ‘hot’ conceptual change should be scaffolded during teacher professional development.

2.6.4. Demystification IKS for Technology Education

The other important factor that will assist in the integration of Indigenous Knowledge in the Technology Education Curriculum is demystification of indigenous knowledge. Despite the important role that Indigenous Knowledge can play, some teachers seem to ignore infusion of Indigenous Knowledge for Technology Education (Owusu-Mensah & Poku 2015). Perhaps this might be attributed to their apprehension of Indigenous Knowledge as enigmatic kind of knowledge and thus not deserving of a space with in the school Curriculum. I concur with Jackson et al (2016), who advises that teachers who are familiar with Indigenous Knowledge will assist students in acquiring pragmatic and Indigenous Knowledge that will allow them to solve problems both inside and outside the classroom. Transferring Indigenous Knowledge from the daily life of the learners to school work is not always valued or encouraged, and some teachers may not recognize indigenous ways of knowing (Owusu-Mensah & Poku 2015). Incorporating IKS into the classroom has the added benefit of helping to demystify the subject and eliminate IKS marginalization (de Beer & Petersen, 2016). Teachers are also concerned that students will ask IK questions to which they will be unable to respond due to a lack of experience (de Villiers et al., 2016). In order to formulate strategies that properly accommodate indigenous students, Technology teachers should be aware of what informs their design concepts.

2.6.5. Teacher agency in terms of improvising shoestring-approaches to Technology Teaching

Technology teaching requires the use of material and some tools during lessons articulating to the success of PAT. This can pose challenge to teachers on under resourced schools and lack of adequate provision of resources. This then calls for teachers to be able to improvise and be able to use limited resource in order to ensure that the register the required success and the achieving of learning objectives. In most South African schools, technology learners cannot afford to bring materials from home to use for their class project (Amato, 2015). I concur with the advice by de Villiers et al (2016) that both pre-service and in-service education programs

emphasize teachers' agencies and shoestring approaches (improvising cheap alternatives).

2.6.6. *Decolonization of the Curriculum by integrating Indigenous Knowledge with Western knowledge forms*

One way to address the challenge of infusing Indigenous Knowledge in Technology Education is to decolonize the Curriculum, in the manner that would guarantee both epistemological and training access (Fomunyam, 2017). Teachers in Technology Education should be able to recognize and accommodate both western and indigenous world views in their classrooms. Decolonization of the Curriculum is discussed in more detail under Section 2.3.2.3 above. Table 2.7 below provides an overview on the distinguishing characteristics between indigenous world views and western world views and how Curriculum decolonization may be achieved by a way of integrating Indigenous Knowledge with western knowledge forms:

Table 2.6: The integration of Indigenous Knowledge with western knowledge forms, as proposed by Gumbo (2020, pp. 29-30)

Indigenous world view informing knowledge	Integration of Indigenous and Western world	Western world views informing knowledge
Spirituality has reference to the entire cosmos	Appreciation and study the universe as an expressed force of the creator to benefit man	Spirituality has reference to a single Supreme being only
Humans have to maintain a harmonious relationship with nature	Adopt a critical approach towards the manipulation of nature and technological designs, and strive for sustainable development	Humans manipulate nature for their own personal and economic gain
There is a need for meaningful interaction between humans and nature, with nature's resources perceived as gifts	Take responsibility for sharing and saving resources for sustainability, being aware of the impact of technology and environment	Natural resources exist for unilateral human exploration
Respect is due to nature due to daily spiritual practice	Values, which include spirituality or religion (for example specialised knowledge), impact on world views; tolerance should be exercised in this regard	Spiritual practices and daily life are not perceived to coexist
The natural world offers wisdom and ethics through direct experience with the nature	Human reason about nature yields insights, which intern enable a better understanding of nature ; thus, better rationalisation and nature should be shown mutual respect	Human reason is above the natural world and likely to produce insight independently
Dynamic, ever-changing natural forces make the universe	There is need to adopt holistic exploration and observation of the universe	The universe can only be understood through an array of static physical object.
The universe is understood to be holistic, integrative system with a unifying life force		The universe is classified according to dualistic forms and it thus reduced to smaller conceptual parts
Time is in tune with natural cycles, which sustain life	Make effort to understand natural factors that impact and determine time, for example, seasonal change, animal behaviour, etc.	Time is linearly and chronologically matched to human progress
Nature will continue to reveal mysteries that challenge human understanding	Nature evolves all the time, opening up for new discoveries and thus bringing dynamism to knowledge	Nature is completely understandable to humans' rational minds
Human thoughts, feelings and words are tied to the universe	Human thoughts, feelings and words are very much shaped by certain environments in the universe	Human thoughts, feelings and words are formed independently of peoples' surroundings
Orderly designs for nature are there for humans to participate in	Treat nature as co-participant in human existence to demonstrate a clear conscious about sustainability	Nature exist purely for humans to dissect, analyse, and manipulate for their own benefit
Elders are respected for their endowment and reconciliation of externally and internally directed knowledge	Nature can be understood through elders' rich knowledge of it. So, paying them respect will facilitate reprioritisation of the approach to materialism	Material achievement and chronological age are determinants for respect for others
A sense of empathy and kinship is formed with other forms of life	Accommodate all forms of life and treat them as equals	A sense of separateness from, and superiority over, other forms of life
Proper human relationships with nature are mutually continuous and informed by transactional dialogue	Human relationship with nature are characterised by feedback loops – that is, nature reacts to what man does to it, and vice versa	Human relationships with nature are linear and hierarchical

2.6.7. *Linking theory and practice in Technology Classrooms*

Most Technology teachers make mistake of assuming Technology Education to be a theory based subject. This often leads to them ignoring the task types that are ideal to facilitate technology in a manner that can ensure the infusion of indigenous knowledge. I concur with the statement by Mapotse (2014, p. 138), who posits that “Another enabler is to link theory and practice in Technology Education classrooms”. I opine that the consideration of the three task types (Case study, Resource Task and Capability task) for Technology Education holds potential to assist Technology teachers to link theory and practice. The case study is ideal to be at the starting of the lesson for the term. This is when the problem is presented to the learners, this then will be followed by the resource task and the capability task. Beginning with the case study assist learners to remain focus so that when the resource task is presented by the teacher (actual teaching), then they are capacitated with appropriate knowledge and skills enabling them to succeed during the capability task (Practical Assessment Task). Table 2.8 below present the summary of the task types:

Table 2.7: A summary of the three task types ideal for Senior Phase Technology as tabulated by Combrinck and Reitsma (2004, p. 62)

Task Type	CASE STUDY	RESOURCE TASK	CAPABILITY TASK
Number of tasks	One	Can be more than one	One (but includes all the steps in the technological process)
Structure	Short, structured	Short, structured	Not structured (it is decided by the learner when following the technological process)
Purpose/ Description of task	- Describes the problem or situation/ he real situation - Examine issues - Links learning in school to experience in real life	Develop and empowers learners with technological knowledge and skills e.g.: - Examine materials - Examine processes - Elements of design - Problem solving	Knowledge, skills and resources are used to apply the technological process to solve the problem: - Analysis of problem - Design of the solution - Development of the product - Making the product - Evaluation of product - Presentation of results
Example	Learners must every day cross a small stream on their way to school. In the rainy season is it very muddy and sometimes too deep to jump over.	Study routes, structures, materials, processes, etc.	Identify problem, possible solution, and plan and make model of small bridge.

2.6.8. Scaffolding Technology teachers' professional development

Within the educational landscape, the term scaffolding" refers a pedagogic process whereby a teacher support and guides their learners through demonstration and modelling of how a solution is sought for an identified problem, while gradually minimising support in order to allow their learners to gain confidence, as well as the necessary knowledge and skills, to eventual be able to solve the problem independently. Scaffolding can be defined as process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner, & Ross, 1976, p. 90) . Scaffolding entails the adult overseeing those aspects of the task that are originally beyond the learner's abilities, allowing the learner to focus on and complete only those components that are within his range of competence (Schwieter, 2010; Sutiarto & Nurhanurawati, 2017). During the scaffolding process, a more competent individual, such as a teacher or parent, provides temporal support to assist a student in establishing a learning task that he or she is unable to develop on his or her own (van Driel, Slot , & Bakker, 2018). The method draws on the principles of the sociocultural theory that stresses the importance of social interaction for learning. According to Vygotsky, children's construction of knowledge is the result of the internalisation of external dialogue that they use when performing a learning task that is guided by a more knowledgeable adult (van Driel, Slot, et al., 2018). The concept of "scaffolding", as applied to the educational context of my study, was introduced by the instructional designer and psychologist, Jerome Bruner, back in the 1960's. According to a definition provided by Bruner (1983, p. 60), "*scaffolding is a process of setting up the situation to make the child's entry easy and successful and then gradually pulling back and handing the role to the child as he becomes skilled enough to manage it*". Although differences of opinion still exist, there appears to be some agreement that scaffolding refers to "*the process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts*" (van Driel, Slot, & Bakker, 2018). Shvarts and Bakker (2019) point out that the concept of scaffolding was also empirically promoted in quantitative research by Wood, Bruner and Ross in 1976. Table 2.9 provides examples of the metaphorical use of the concept *scaffolding* between 1812 and were metaphorically used

Table 2.8: Examples of the metaphorical use of ‘scaffolding’ in literature as posited by Shvarts and Bakker (2019, p. 8)

Author, year	Original Terminology	Context (interpretation)	Metaphorical connotations
Hegel, 1812	Gerüst (German), in English translated as scaffolding	Categorical consequences of sensory experience as an illusion of scaffolding of a physical law’s proof. It falls away at the next turn of scientific endeavor, but its core may be preserved due to the peculiarity of sublation	– Skeleton of a building – Temporary construction
Marx, 1847	Échafaudage (French) (in Russian translated as здания, строительные леса)	A skeleton of categories as a scaffolding of ideas that is empty and arbitrary unless the categories have immersed in practice and obtained from there in the analysis	– Skeleton of a building – Temporary construction
Lenin, 1901, and other revolutionaries	Строительные леса	Support for the process of ideology spreading or of establishing of communism. The revolutionary means are temporary until the building of Communism will stand on it’s own.	– Temporary construction – Support of the workers or of the building
Vygotsky, 1929	леса	An analogy between a word and an instrument as the scaffolding of the future theory. Approximation of the future theory by previous theoretical construction.	– Temporary construction – Approximation of a future building
Luria, 1929	“в лесах”	A description of walking skill at the early stages of development: a child is supported by external objects and a parent’s hands while walking, and later this function is replaced by internal neuro-dynamic processes.	– Temporary help by external tools – Replacement of a scaffold by the built construction
Bernstein, 1947 and approximately 1949	Строительные леса	A metaphorical description of the development of motor control functional system that consists of a leading level and lower levels. The leading level plays a role of scaffolding for the background levels. In 1949 this process is explained by two metaphors: (i) “crutches” take part in realization of the action and (ii) “scaffolding” provides the sensory feedback about the action fulfillment	– Temporary help by external tools – Replacement of a scaffold by the built construction

Pressly (2002) provides an interesting analogy of scaffolding using the construction of a house as an example, his example states that:

“when a building is to be constructed, it cannot stand on its own without supports around it. However, when the construction stage is completed, the support is removed to let it stand freely. This is similar to what happens in the teacher-student/adult-child interaction in the course of mental development. The teacher/adult provides student/child assistance to the extent that the scaffolded individual can do the task in hand by himself” (Pressly, 2002 cited by Ameriana and Mehrib, 2014, p. 759).

The above analogy signify that during the scaffolding process, a more knowledgeable other, such as a teacher or parent, offers temporal backing to help a learner to create a learning task that he or she cannot yet launch alone (van Driel, Slot , et al., 2018).

In their seminal work, Shvarts and Bakker (2019) provide examples of the metaphorical use of scaffolding in the literature (Table 2.9). Shvarts and Bakker (2019) concludes that the important component of “scaffolding” as a concept is that it provides a transitory quality of assistance and formation of a new efficient structure by means of a responsible relationship between the teacher and the student, which leads to students’ becoming self-reliant in order to solve problems they previously was unable to mitigate. Thus, scaffolding can effectively be used as a teaching method to infuse Indigenous Knowledge in the technology classrooms.

As a teaching method, scaffolding draws upon the principles of the sociocultural perspective posited by Vygotsky (1978) that elude the significance of social interaction for learning. Vygotsky (1978) asserts that construction of knowledge is the product of internalization of external dialogue that they use when performing a learning task that is guided by a more knowledgeable adult. From this sociocultural perspective or Vygotskian perspective, learning is perceived as a socially situated action through which a learner initially only attain in a social setting until ultimately he or she matures to acquire knowledge self-reliantly (Bassiri, 2012). Vygotskian perspective succinctly underpins constructivism as a focal theory in teaching and learning and thus expound on the three main assertions namely “Social interaction, More Knowledgeable Other (MKO) Zone of Proximal Development (ZPD)” (Abtahi, 2017; Abtahi, Graven, & Lerman, 2017). The following section provides a brief exposition about Social interaction, More Knowledgeable Other (MKO) Zone of Proximal Development (ZPD).

Social interaction plays an essential part in the improvement of cognitive development (Turner, 1989). Social interaction is regarded as a state where the behaviours of one actor are deliberately reorganized by, and guides the behaviours of, another actor, and vice versa. Instead of learning a set knowledge base, students develop evolving knowledge bases through their interactions with others (Roehler & Cantlon, 1997). This internalization process starts on a social level and progresses to an inner level, where information is assimilated into an individual’s growing knowledge base. (Roehler & Cantlon, 1997).

Due to its sought multidimensional approach, which pays special attention to the cognitive, affective, social, and contextual elements of change, Vygotsky's learning theories appear to be paramount to current models of learning and development (Shabani, 2016). The premise that individual learning is dependent on social interaction, according to Van Oers (1996) is one of the underlying tenets of the Vygotskian approach to education. The social constructivist model assumes that all knowledge is social in nature and that learning takes place in the context of social relationships that lead to a better understanding (Roehler & Cantlon, 1997).

(i) More Knowledgeable Other (MKO)

The MKO refers to someone who has a better understanding or a higher ability level than the learner with respect to a particular task, process, or concept (Siyepu, 2013). The Vygotskian viewpoint means that we learn best when we are surrounded by others with a better understanding of certain historical and cultural practices, others who are more knowledgeable (Abtahi, 2017). Initially, the teacher or more knowledgeable person controls and guides the learners' activities. Eventually, the teacher and learners share the responsibilities with the learners taking the lead (Roehler & Cantlon, 1997).

(ii) Zone of Proximal Development (ZPD)

From Vygotsky's social constructivism, which is discussed in Section 3.2.1 above, emerged the *Zone of Proximal Development (ZPD)*. Vygotsky (1978, p. 86) defines the zone of proximal development as: *"the distance between the actual developmental level, as determined by independent problem solving, and the level of potential development, as determined through problem-solving under adult guidance, or in collaboration with more capable peers"*. ZPD embodies a phase in the development of a learner where the learner is incapable to execute an assignment single-handedly but can ultimately complete it with the assistance and direction of somebody more knowledgeable (Christmas et al., 2013). Buttressing this notion (Hausfather, 1996) identified three distinctive characteristics of the zone of proximal development:

- The paramount means to apprehend the mind is to look how it transforms
- The advancement of intellectual functions have their origins in social activity.
- Advanced perceptual functions are facilitated by tools and signs.

Drawing from these three distinctive characteristics, as postulated by Hausfather (1996), this study then contextualised the zone of proximal development (ZPD) perspective of Vygotsky (1978), in the parlance of Warford (2011), who coined the term "zone of professional teacher development (ZPTD)" for the development of a short learning programmes to capacitate teachers with pedagogical skill and content knowledge in order to effectively infuse indigenous

Knowledge (IK) in their technology classrooms. As elucidated in chapter one, this study conceives the zone of professional teacher development (ZPTD), as described by (Warford, 2011). According to Warford (2011, p. 253), the zone of proximal teacher development (ZPTD) *“denotes the distance between what teaching candidates can do on their own without assistance and a proximal level they might attain through strategically mediated assistance from more capable others”*. Fania and Ghaemib (2011) add that the ZPTD advances methodically, as the understanding of teaches is persistently re-shaped to house the vigorous nature of the classroom environment. Constructivists hold the view that there is a constant bond between what is to be learned by a learner, and what a learner already knows (Harland, 2003). For this reason, teachers are therefore strategically positioned to create conducive atmospheres for meaningful learning that would stimulate positive interdependence through scaffolding and collective learning (Morcom, 2014). Good teaching practice should be designed for the learner’s ZPD that will enable learners to draw upon the knowledge and expertise of their teachers, when they find certain activities challenging to execute (Macy, 2016).

One outstanding facet of Vygotsky’s theory is the notion that the underlying aspect for cognitive development is subject to the “zone of proximal development” (ZPD), which is achieved when people participate in social actions (Tayebeh & Ghaemib, 2011). From a social constructivist perspective, optimum learning occurs within the zone of proximal development (Roehler & Cantlon, 1997). Most scholars agree that scaffolding is manifested within the Zone of Proximal Development (Ameriana & Mehrib, 2014; Warford, 2011), as *“the distance between what teaching candidates can do on their own without assistance and a proximal level they might attain through strategically mediated assistance from more capable others (i.e. methods instructor or supervisor)”* (Warford, 2011, p. 253). Holding a similar view Pea (2004), adds that the zone of proximal development (ZPD) in the understanding of scaffolding is worth noting because of its socio-participatory character regarding teaching and learning. Within education, scaffolding may be employed in range of circumstances. Figure 2.5 shows the attributes of purposeful scaffolding, identified by Sam (2011, p. online).

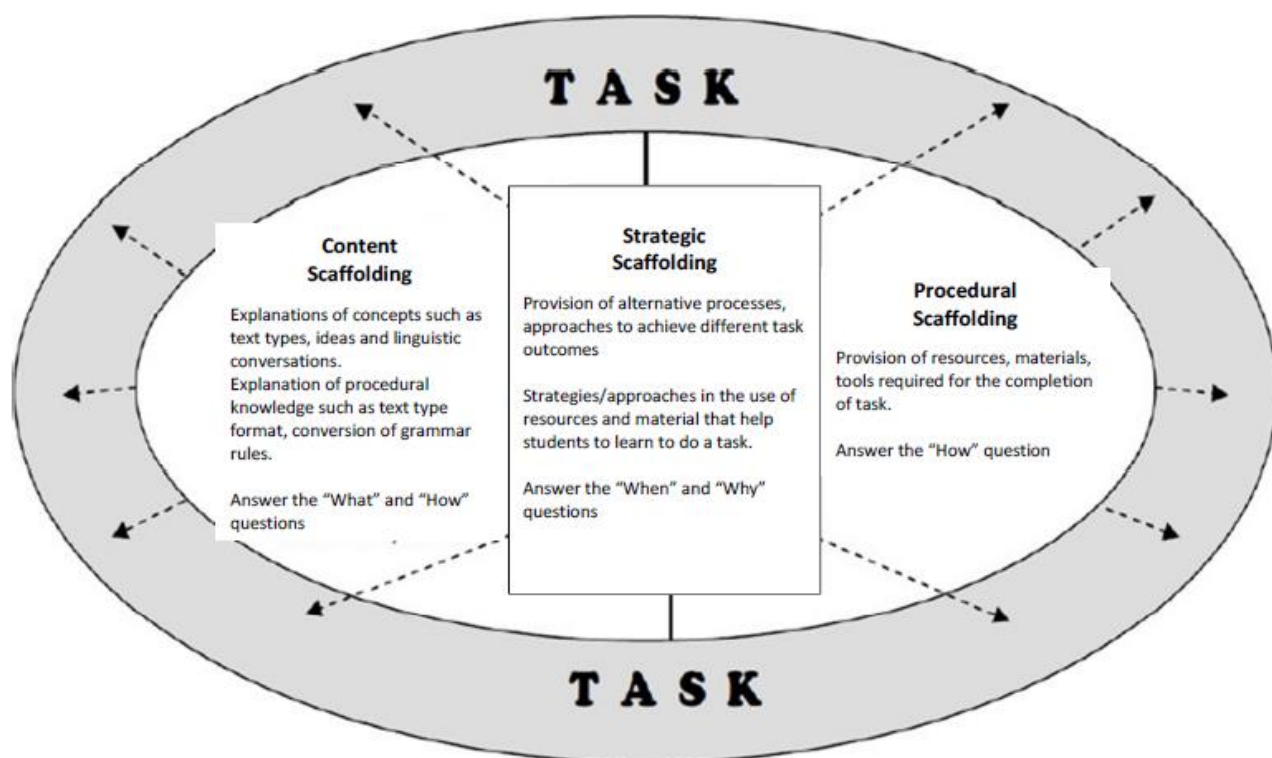


Figure 2.5: Attributes of purposeful scaffolding, as identified by Sam (2011, p. online)

From the above exposition it becomes clear that scaffolding is characterised by the social interaction that occurs among students and teachers that precedes internalisation of the knowledge, skills and dispositions deemed valuable and useful for the students (Roehler & Cantlon, 1997). Scaffolding leads to the gaining of knowledge and skills, so that students can function independently in the future (Roehler & Cantlon, 1997). Working within developmental models, teachers use evidence of student learning to identify students' ZPDs. This represents student readiness where targeted intervention produces maximum impact and the scaffolding of this learning will move students to learn faster along a path of increasingly complex competence, knowledge and skills (Zakaria, Care, & Griffin, 2016). Scaffolding, therefore, is supporting students in learning and problem solving, which includes providing clues, encouragements, examples and modelling, which will encourage students to grow independently (Padmadewi & Artini, 2018)..

2.6.9. Development and delivery of short-learning programmes for continuous teacher professional development with regard to the infusion of Indigenous Knowledge into Technology Education

The final enabler for the effective infusion of Indigenous Knowledge into Technology Education, is to develop and deliver short-learning programmes for the continuous TPD of Senior Phase Technology teachers. This is exactly what I did in my qualitative case study. Chapter 3 elaborates on how I developed and presented a short-learning programme on the infusion of Indigenous Knowledge into Technology Education, to Senior Phase Technology teachers over three intervention cycles. The findings obtained from the qualitative data generated during the three intervention cycles, are reported in Chapter 4. The findings from this literature review chapter are combined with the qualitative findings reported in Chapter 4, in order to distil design principles in Chapter 5, for future short-learning programmes on the infusion of Indigenous Knowledge into Technology Education.

2.7. Summary of Chapter 2

Chapter 2 constitutes the Literature Review of my qualitative case study. The chapter opens with an exposition of the ontological looking glass that I used during my investigation, i.e. Ubuntu, the African philosophy of Life and Education. Then Social Constructivism is discussed as the higher order theoretical construct of my study. Furthermore, a distinction is made between various lower order constructs, which together, constitute the conceptual framework of my research. These include: Cultural Responsive Theory, the continuous professional development of Technology teachers, the reformation and decolonisation of the school Curriculum, the origins, core content areas and objectives of Technology Education in South Africa, self-directed learning, and problem-based learning. Next, Indigenous Knowledge Systems and Indigenous Technologies were explored, followed by a discussion on the andragogical and pedagogical infusion of Indigenous Knowledge into Senior Phase Technology Education. Cognisance was taken of two existing frameworks for the infusion of Indigenous Knowledge into Technology Education, i.e. (i) Gumbo's (2018) adaptation of Seemann's (2000) Technancy Framework for Technology Education, and (ii) the Cultural Responsive Teaching Theory Framework, first proposed by King, Artiles and Kozleski (2009), and later adapted by Gumbo (2018). The chapter furthermore identified various barriers and challenges that still restrict the effective infusion of Indigenous Knowledge into Technology Education, also identified possible solutions from the literature to overcome these barriers and challenges

Chapter 3

Research paradigms, research design and methodology

Tselanakgopo ga e latse nageng

(The winding path does not let you spend the night in the veld)

Chapter 3

Research paradigms, research design and methodology

3.1. Introduction

In this chapter, I indicate how two research components of my qualitative case study are anchored within the *constructivist* and *interpretivist* research paradigms. Next, I explain how I made use of a design-based research approach, consisting of three intervention cycles pertaining to a short-learning programme, delivered to senior phase Technology teachers, on the infusion of Indigenous Knowledge into Technology Education. From these progressive intervention cycles, design principles are distilled in Chapter 5 for the development of related short learning programmes in the future. This chapter furthermore describes and motivates the choice of my research design and methodology, and provides a comprehensive account of the sampling technique and selection criteria that I followed, the nature, size and demographic information of my research sample, and the ethical considerations that guided the study. The chapter continues to elucidate the different qualitative data collection methods that I used to generate qualitative data, and accordingly to create an integrated hermetic unit for my qualitative data analysis. Chapter 3 ends with a discussion of the data analysis strategies and procedures that I followed, in order to conduct my qualitative data analysis on the integrated dataset.

3.2. Research Paradigms

Sociological research paradigms are applicable to my educational research, as education is considered to be an interdisciplinary social science. Burrell and Morgan (1979), which is regarded as a foundation text in the field of sociological paradigm theory, argue that social theory can usefully be conceived in terms of four meta-paradigms, based upon different sets of meta-theoretical assumptions with regard to the nature of social science and the nature of society. The “four meta-paradigms, i.e. Functionalist, Interpretive, Radical Humanist and Radical Structuralist, are derived from quite distinct intellectual traditions, and present four mutually exclusive views, which stand in their own right, and generate their own distinctive approaches to the analysis of social life” (Burrell & Morgan, 1979, p. 25).

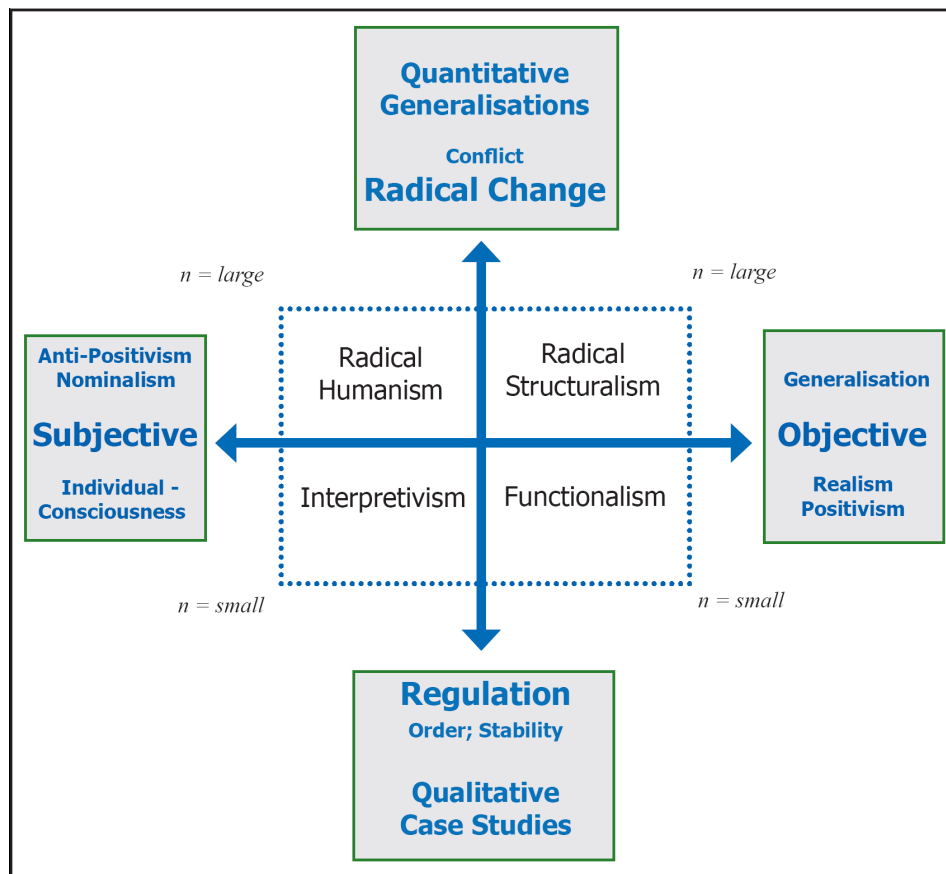


Figure 3.1: Social Research Paradigms (Els and Blignaut (2013), adapted from Burrell and Morgan, 1979, pp. 29-30)

The horizontal axis on Figure 3.1 represents the subjective versus the objective continuum. The subjective side concerns individual consciousness and unique case studies and is ontological nominalistic. “Nominalism believes the world external to individual cognition is made up of words, names, concepts and labels that people use to describe and structure reality according to their experiences. Objectivism, on the other hand, deals with ontological realism. Realism rests on an external world outside the cognition of the individual hard, tangible and immutable structures” (Burrell & Morgan, 1979, p. 25). The objective side is epistemologically positivistic and explains phenomena by searching for regularities and causal relationships. The subjective side is epistemologically anti-positivist. It understands and relates subjective involvement and relativistic laws or underlying regularities in the world.

The “vertical axis of Figure 3.1 represents the regulation (order and stability) versus the radical change (conflict and transformation) continuum of research. Regulation speaks to theories and explanations of the cohesiveness of the world as well as to the regulation of human affairs. Radical change, on the other hand, explains radical change, deep-seated structural conflict, modes of domination, and structural contradictions that characterise society and the science of

educational technology. Radical change also focuses on human deprivation, both physical and psychological, in order to identify the factors that limit humanities' development. Radical change typically looks at human potential and ways to transform human development. Quantitative evaluations aim to radically change technology, education, and society by implementing science and philosophy" (Burrell & Morgan, 1979, p. 28). These two axes divide Figure 3.1 into four meta-paradigms: radical humanism, radical structuralism, functionalism, and interpretivism.

Radical Humanism (Subjective Quantitative Research Components)

According to Burrell and Morgan (1979), the "radical humanist paradigm focuses on the radical changes in society, education, or technology from a subjectivist standpoint. Radical humanism argues that a human consciousness is dominated by ideological superstructures. These superstructures drive a cognitive wedge between humans and consciousness. This wedge of alienation and consciousness inhibits human fulfilment. Therefore, radical humanism believes the constraints social arrangements place on human development should be loosened, in order to realise human potential. Central emphasis is placed on the development of human consciousness and potential through radical change and liberation from ideological superstructures. Radical humanism explores repression, liberating potential, and rights of minority groups" (Burrell & Morgan, 1979, p. 32).

Radical Structuralism (Objective Quantitative Research Components)

The "radical structuralist paradigm investigates radical change in society, education, or technology from an objective and empirical standpoint. Radical change looks at human potential, as well as objective, conflicting and contradicting influences that limit human potential" (Burrell & Morgan, 1979, p. 33).

Functionalism (Objective Qualitative Research Components)

The "functionalist paradigm addresses realistic and objective evaluations to maintain stability and order in organized structures. Its evaluation is realistic, positivistic, deterministic, and nomothetic" (Burrell & Morgan, 1979, p. 25). Because functionalism is primarily pragmatic (gains knowledge, puts knowledge into use, and provides solutions), evaluation components are anchored in this meta-paradigm. Typical functionalist research components include: case studies, programme evaluations, implementation evaluations, programme monitoring, process evaluations, needs assessments, impact assessments, outcome assessments, progress assessments, management evaluations or infrastructure. The functionalist approach assumes,

applied to the context of this study, that the various aspects of Technology Education are concrete, objective and empirical, and can be studied, measured, and improved through approaches commonly used in natural and formal sciences. Small research populations in functionalist evaluations facilitate the objective monitoring and impact assessment of, for example a short learning programme on the infusion of Indigenous Knowledge into Technology Education, in order to improve the effectiveness of similar future learning programmes by distilling design principles for them. “Other paradigms that may be grouped under the functionalist meta-paradigm are: **constructivism** (how people construct meaning from their current knowledge), ethno-methodology (how people make sense of their world), and Naturalism (the study of natural contexts)” (Burrell & Morgan, 1979, p. 25). *The research component of my study, in which I distil (in Chapter 5) design principles for the development of future related short learning programmes, is based upon my objective qualitative analysis of the combined corpus of findings that I gained upon my research journey. This includes the findings from my literature review (Chapter 2), the findings of my qualitative case study (Chapter 4), as well as the objective observations and conclusions I made, which is anchored within the Constructivist research paradigm and falls under the meta-paradigm of Functionalism.* This paradigm is anchored in Constructivism, furthermore relates to social constructivism, as one of the philosophically underpinnings of my study (discussed in Chapter 2), i.e. that meaningful learning is a result of a collective effort between the lecturer-researcher and teacher-students, as well as between teachers and their learners, ensuring that knowledge acquisition is as a result of the interaction within their socio- cultural context (Vygotsky, 1978).

Interpretivism (Subjective Qualitative Research Components)

The “interpretivist paradigm addresses subjective experiences that shape order and stability” (Burrell & Morgan, 1979, p. 29). Within the context of the current investigation, this typically could include the subjective attitudes, needs, challenges, and experiences of my participants, with regard to their integration and use of Indigenous Knowledge and skills to attain professional development into the core content areas in the senior phase Technology Curriculum. “Other paradigms under the interpretivist paradigm include: phenomenology (subjective structures of consciousness — people’s direct experience of the world); symbolic interactionism (people’s actions toward things based on language and symbols — meaning is derived from social interaction and modified through interpretation); hermeneutics (people’s interpretation of the world through language and non-linguistic expressions); and existentialism (how people create their own meaning and essence through their existence)” (Burrell & Morgan, 1979, p. 29). The research component of my study in which I investigated the subjective qualitative attitudes, needs, challenges, and experiences of my participants, with regard to their integration and use

of Indigenous Knowledge and skills to attain professional development into the core content areas in the senior phase Technology Curriculum, is anchored within the Interpretivist meta-paradigm.

3.3. Research Design and Methodology

In this section, I share something about myself as researcher, and then discuss the qualitative case study research design that I followed for my investigation, as well as the various types of qualitative methods that I used for data collection.

3.3.1. *Something about me as Researcher*

I worked as a Technology Education teacher in a South African public school for 15 years and hold a Master's Degree in Curriculum Studies (Technology Education). At the commencement of this study, I was employed by a Higher Education Institution in South Africa and is responsible for several Senior Phase Technology Education modules. Participants in this study had no prior contact or relations with me as the researcher, therefore there was no potential risk of conflict of interest or biasess that could jeopardise the intergrety of my research. As part of my 84tilized84z professional development, I gained knowledge and practical skills in research, while successfully completing both a Honors Degree in Education (Bed Hons), as well as a Masters' Degree in Education. In addition to the knowledge and skills I gained in qualitative research, encompassed by my formal academic qualifications, I also pursued more specialised training in qualitative research, by means of short-courses and workshops, in order to adequately prepare and skill myself for the purpose of conducting this qualitative case study.

3.3.2. *Qualitative Case Study Research Design and Methods of Data Collection*

In order to reach an in-depth understanding of the attitudes, needs, challenges, and experiences of senior phase Technology teachers, who participated in a short learning programme regarding the infusion of Indigenous Knowledge into Technology Education, qualitative research was deemed appropriate for my study. Hancock (1998) argues that a qualitative research design is appropriate to obtain comprehension, examine the extent, fullness, and multiplicity deep-rooted in the aspect under study. Yin (2011, p. 9) adds that "*qualitative research strives to collect, integrate, and present data from a variety of sources of evidence as part of any given study*". Accordingly, I followed a qualitative case study research design, and generated data using the following qualitative methods of data collection: (i) a qualitative open-ended questionnaire, (ii) teachers' self-reflective sheets, (iii) a focus group interview with teachers, (iv) teachers'

portfolios, (v) teachers' indigenous technological artefacts, as well as (vi) teachers' collaborative mind maps.

3.3.3. Design-based research approach consisting of three intervention cycles

I made use of a design-based research approach, consisting of three intervention cycles, pertaining to a short-learning programme delivered to senior phase Technology teachers. This was part of their continuous professional development, regarding the incorporation of Indigenous Knowledge into Technology Education. From these progressive intervention cycles, design principles were integrated in the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education. For Armstrong, Dopp, and Welsh, (2020), design-based research in education is a research methodology that uses iterative designs to produce information that improves educational practices. The intention is to investigate the possibilities for educational improvement by bringing about new forms of learning in order to study them. Consequently, there is frequently a significant discontinuity between typical forms of education (these could be studied naturalistically) and those that are the focus of a design experiment (Cobb, Joseph and Bielaczyc, 2004, p. 10). Figure 3.2 postulates what Armstrong, et al (2020), dubbed as the iterative process of the design-based research.

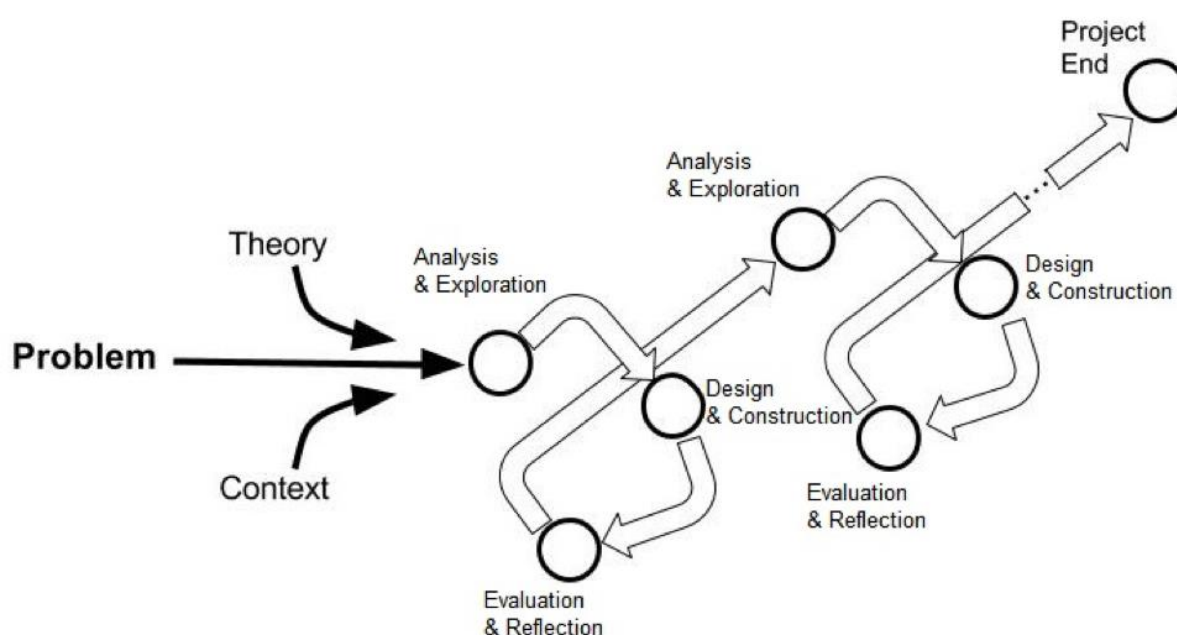


Figure 3.2: The Iterative Process of Design-Based Research as posited by Armstrong, et al. (2020, p.4).

DBR is an optimum strategy to conduct research that ensures that the researcher is able to strike the correct balance between theory development and practical application (Collins, 1992, Collins et al., 2004). Collins, Joseph and Bielaczyc (2004), explain that the design-based research approach was first introduced by Brown (2009), who made use of repeated cycles of

design, implementation, analysis, and revision, within their research. The infusion of IK is often ignored in Technology and as a results pushed to the peripheral space. This robs the learners of the rich culturally accumulated knowledge that can be drawn from their diverse cultures. Consequently, in order to assist the study participants to infuse IK, participants in each of the intervention cycles where required to reflect on their practice, from which challenges were identified, this informed the improvement done on the following intervention cycles. A design-based research approach was ideal for my investigation, as it allowed me to develop and deploy appropriate interventions, and at the same time, to cultivate theoretical knowledge on how to scaffold the professional development of Technology teachers who were using Indigenous Knowledge into their classrooms. A design-based research approach allowed for the progressive implementation of multiple interventions that were meaningful to such a degree and to ensure that my expertise on how to infuse Indigenous Knowledge in Technology Education was successfully transferred to the participating Technology teachers. According to Štemberger and Cencič (2016, p. 181) *“when the aim of the research is innovation in educational practice, the research should be oriented towards helping teachers acquire the necessary knowledge and skills to properly implement the innovation”*. Similarly, Design-Based Research Collective, (2003) allude that a design-based research approach is applied in order to ensure that the study outcomes are ultimately transferable to classroom practices. For Anderson and Shattuck, (2012a), such intervention should form a mutual beneficial relationship between both researchers and teachers as practitioners in the classroom. By employing a design-based research approach, one ensures that there is a shift from traditional research to a more pragmatic approach in addressing classroom challenges. Furthermore, Anderson and Shattuck (2012 p 16), notes that design-based research *“is designed by and for educators that seeks to increase the impact, transfer, and translation of education research into improved practice”*. In Design-Based Research knowledge is gained in the form of design principles (Cotton, Lockyer, & Brickell, 2009).

Another crucial facet of design-based research is its emergence as a reaction to mitigate for the inequities of some research approaches in order to tie theory and practice as a means of generating useful knowledge to guide educational practice (Alghamdi & Li, 2013). The ability of

aligning theory and practice in educational research context relies on the collaboration between researchers and participants. Previous studies on design-based research demonstrate that when employing design-based research, participants and researchers work together to produce meaningful change within their specific contexts as a result of their collaborative engagement (Anderson & Shattuck, 2012b; Cotton et al., 2009). In this study, I collaborated with Senior Phase Technology Education teachers in two provinces, the Northern Cape Province and the North-West Province, to scaffold the infusion of Indigenous Knowledge into their Technology classrooms, promoting both transfer in the classroom, and self-directed learning (Berry, Daughtrey, & Wieder, 2009). This collaboration has ensured that my research goals and design were aligned with my research context, as well as my research agenda, in line with what Robinson (1998) suggests. I furthermore concur with Barab and Squire, (2004, p. 2) who posit that *"The partnership in a design-based study recognizes that teachers are usually too busy and often ill trained to conduct rigorous research"*. The purpose of the interventions was therefore to ensure that Technology teachers are adequately capacitated to incorporate Indigenous Knowledge in their classrooms. Furthermore, the other key advantage of employing design-based research was due to its focus grounding the study on the real-world practice and context of the Senior Phase Technology Education teachers (Barab & Squire, 2004). The study included three intervention cycles, during which the short learning programme was presented in two provinces. The nature of design-based research is pragmatic because it ensures that the phenomenon under investigation is in its natural world which ensures that the interventions and the theories developed from generated data are concise (Bournot-Trites, 2017). Hoadley (2004, pp. 205-206) argues that design-based research as *"research on collaboration adds design complexity; it is particularly sensitive to variations in context, and any intervention reverberates through the setting changing both the individuals and the social context"*. Furthermore, the significance of following a design-based research approach lies in the interactive nature of my research process that does not just appraise the product of the intervention, but methodically endeavours to cultivate the improvement while also creating design principles (Amiel & Reeves, 2008).

In my design-based research study the short learning programme was conceptualised according to the insights of Vygotsky (1978), who perceive learning as occurring on two levels or planes. On the first plane, teachers socially construct learning, by engaging in, for the purpose of this investigation, the infusion of Indigenous Knowledge in the Senior Phase Technology Education Curriculum themes. On the second plane, teachers internalised this knowledge during reflective activities. In true design-based research fashion, the short learning programme evolved over several cycles of implementation. After each cycle, design principles were distilled,

to inform the next cycle. The intent of this qualitative case study was for such meaningful learning to occur within the *Zone of Proximal Teacher Development* (Warford, 2011).

Accordingly, the following three intervention cycles were progressively implemented, pertaining to a short-learning programme delivered to senior phase Technology teachers, as part of their continuous professional development, on the infusion of Indigenous Knowledge into Technology Education:

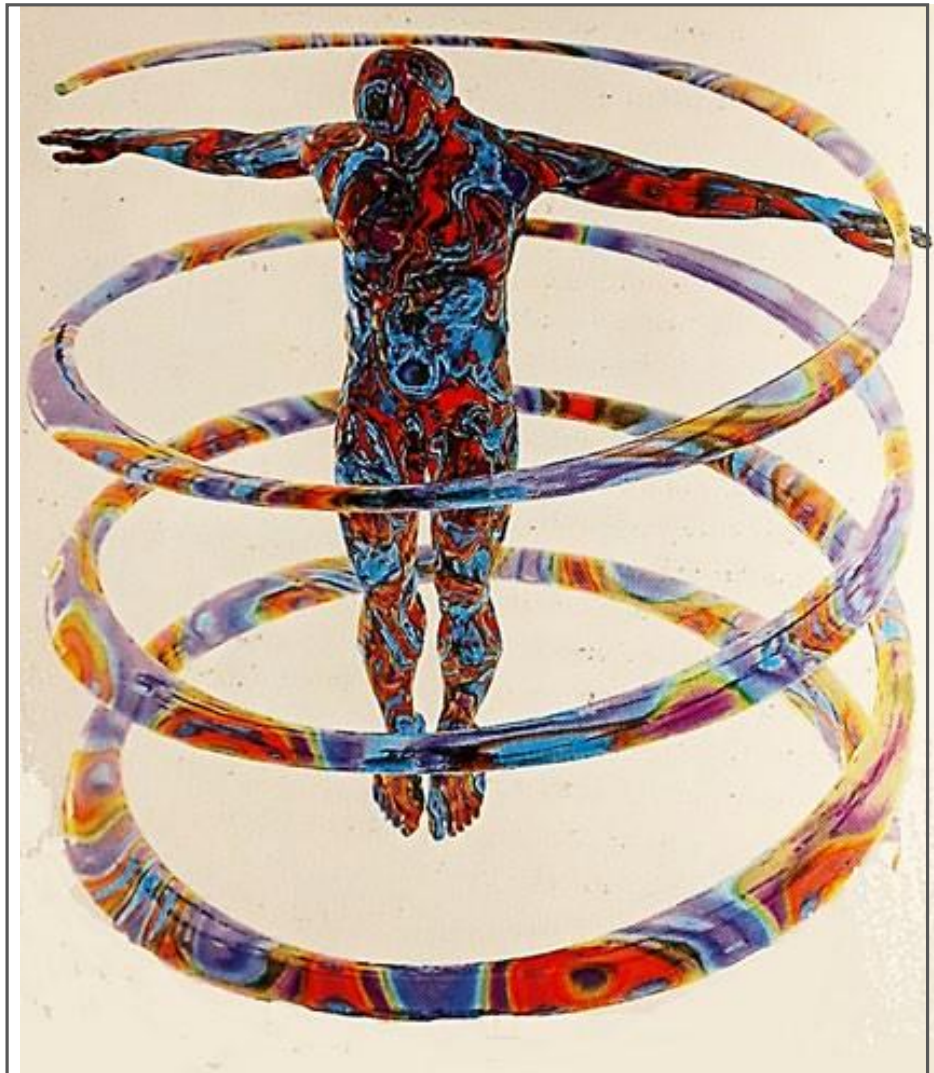


Figure 3.3: A graphic artist's symbolic visual representation of the three intervention cycles of the design-based research approach that was used for the continuous professional development of Senior Phase Technology teachers, with regard to the infusion of Indigenous Knowledge into their classrooms.

1ST INTERVENTION CYCLE: POTCHEFSTROOM, NORTH-WEST PROVINCE

The North-West University conceptualized and developed a three-day short learning programme (SLP) in IK for Technology teachers. This course was designed for the development of the knowledge, skills and attitudes of Technology teachers with regard to indigenous knowledge, so that the teachers would have the knowledge and skills to facilitate the epistemological border-crossing between the contents of the formal Technology Curriculum, and Indigenous Knowledge systems. During the 1st intervention cycle, the three day, NQF Level 6 (16 credit) course was presented in 2016 in the North West Province. As part of this 1st intervention cycle, the programme on the first day included a visit to the one of the Museums in the North West Province, namely the Mphebathe Museum, in Moruleng where participants interacted with the holders of Indigenous Knowledge (especially related to the Bakgatla indigenous knowledge). The strong focus during the three-day course was to package the CAPS Curriculum in such a manner, that the participants experienced the content as authentic and relevant. The design of the short course was grounded by the principles of self-directed learning (Chapter 2). Knowles (1975) describes self-directed learning (SDL) as a process by which individuals take the initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. Furthermore, apart from the focus on indigenous knowledge, the first intervention cycle also emphasized cooperative learning, problem-based learning and the role of reflection. Participants in the first intervention cycle were five Senior Phase Technology teachers, who upon completion of the three day course were required to submit a portfolio in which they reflected on Pedagogical Content Knowledge (PCK), future professional development needs, and planning, in order to promote both the transfer of Indigenous Knowledge and self-directed learning in their classroom practice. The photos below are of participants engaging with holders of Indigenous Knowledge at Mphebathe Museum who demonstrated indigenous leather tanning and food processing.



Figure 3.4: Photographic evidence of participating teachers engaging with IK holders at Mphe batho Museum while IK holder demonstrated the leather tanning process. (Photographer: J. de Beer. Photograph published with the written consent of all participants).



Figure 3.5: Photographic evidence of teachers participating in grinding maize to make stamp as part of food processing. Photograph: J. de Beer. Published with the written consent of all the participants.

2ND INTERVENTION CYCLE: NAMAQUA DISTRICT, NORTHERN CAPE

During the 2nd intervention cycle, the NQF Level 6 (16 credit) course was presented to senior phase Technology teachers in the Namakwa district of the Northern Cape Province in 2017. The Namakwa district is home to Indigenous Knowledge holders that possess an accumulated body of knowledge and skills that are embedded in their close relationship with this geographical location and natural environment (Mapara, 2009; Odora-Hoppers, 2002). The SLP was designed to enable educators to integrate local IK as a learning outcome in the Technology Curriculum through classroom-based activities and teaching strategies. Completion of the course required teachers to submit a portfolio demonstrating the application of what they learnt into their classrooms.

The intervention utilized a design process approach to expose Technology teachers to innovative teaching strategies, PCK and IK. Theoretically, the design process is an experience-based programme that engages learner curiosity and creativity to meet the needs of humanity (Pudi, 2007). The process is embedded in the Technology Curriculum in intermediate, senior and FET phases encompassing problem solving and design, resources and materials problem solving, technical systems, resources and materials, criteria and constraints, optimization and trade-offs and many other human topics (Dugger & Naik, 2001). The technology subject demands that teachers integrate theory and practice in order to engage learners and foster 21st century skills. Integrating theory and practice requires that Technology teachers employ the design process as the foundation for Technology teaching.

The design process is the “core of the practice of technology” (Franssen, Lokhorst, & Van de Poel, 2013). The process includes a configuration of steps and criteria for solving an identified problem (De Vries, 2012). The steps can be linear or cyclical. Figure 3.6 is a representation of the six-step cyclical design process modelled in the intervention.

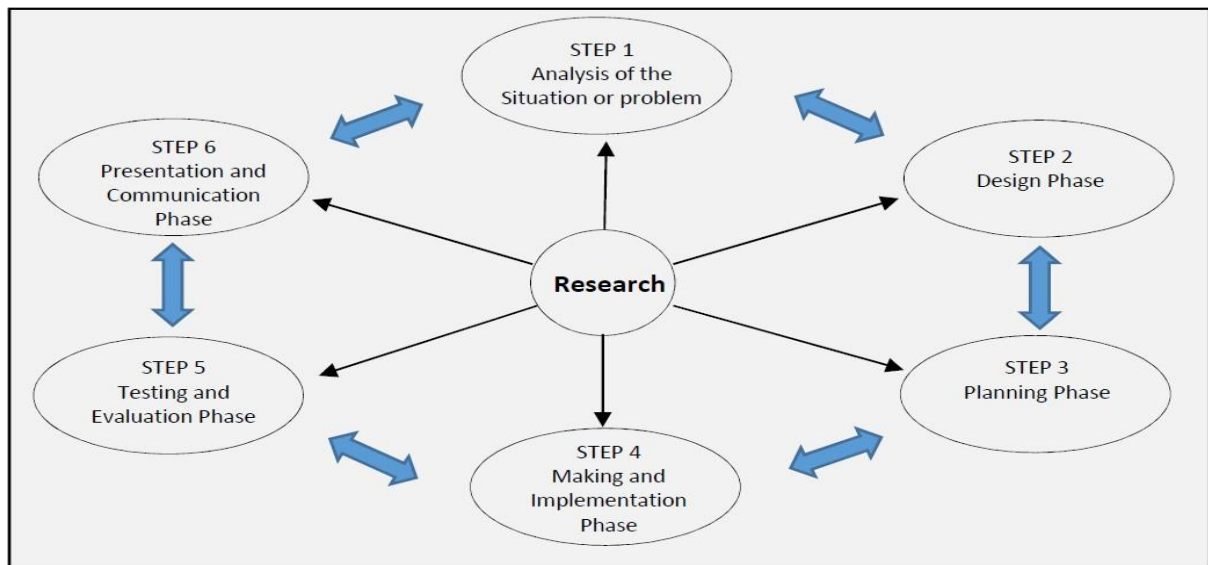


Figure 3.6: Six Steps Cyclic Representation of the Design Process (Combrinck & Reitsma, 2004)

Criteria or requirements are embedded in each step, therefore following the steps generates a conceptual solution to the problem (2016 Online). Senior phase Technology learners are required to follow the process, create a solution and implement the solution. The Department of Basic Education (2011) coined the process as IDMEC (Investigate, Design, Make, Evaluate and Communicate). Learners follow these steps to identify problems and generate answers to the identified problems.

Participants in the second intervention cycle were eight senior phase Technology teachers, all males, who attended the Short Learning Programme, per invitation and organized by the NWU in the Northern Cape Province in the Namaqua District (in the town of Calvinia). These eight participants, were qualified teachers with no formal training in the teaching of the subject Technology. These participants originally taught other subjects, including Wood Work, Carpentry including Arts and Craft. As per the SLP requirements, participants in the study were required to submit self-reflection sheets in which they reflect on both their daily classroom practice and the impact of the SLP regarding the infusion of Indigenous Knowledge in their technology classrooms. A convenience availability sampling strategy was used, as all teachers attending the course also participated as research participants. During the second intervention cycle, I made use of third generation Cultural Historical Activity Theory (CHAT) as a research lens to explore the challenges experienced by senior phase Technology teachers when applying intervention knowledge and skills in their classrooms. According to Taylor (2014, p. 96), “*CHAT is appealing because, like other approaches embedded in a dialectical tradition, it aims to understand how to create the conditions for full human development*”.

3RD INTERVENTION CYCLE: DR. KENNETH KAUNDA DISTRICT, NORTH-WEST PROVINCE

The 3rd intervention cycle, involved five Technology teachers, who attended a three day Short Learning Programme in 2019 in the North West Province during which Indigenous Knowledge was implemented and used for teachers' continuous professional development with regard to the core content areas in the Senior Phase Technology Curriculum.

A purposefully selected availability sampling technique was used in the 3rd intervention cycle of this investigation to invite the senior phase Technology teachers, who attended the course, to voluntarily and anonymously participate in this case study. According to Tongco (2007), a purposive sampling technique is a type of non-probability sampling that is most effective when one needs to study a certain cultural domain using knowledgeable experts within.

Table 3.1: Demographical Profile of Senior Phase Technology teachers who participated in the 3rd Intervention Cycle of this Qualitative Case Study Investigation

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
GENERAL DEMOGRAPHICAL INFORMATION					
Gender	♀	♂	♂	♀	♂
Cultural language group	Coloured Afrikaans	Coloured Afrikaans	Setswana	Coloured Afrikaans	Setswana
Province	North-West	North-West	North-West	North-West	North-West
District	Dr. Kenneth Kaunda	Dr. Kenneth Kaunda	Dr. Kenneth Kaunda	Dr. Kenneth Kaunda	Dr. Kenneth Kaunda
Municipality	Tlokwe	Tlokwe	Tlokwe	Tlokwe	Tlokwe
Township	Promosa	Promosa	Ikageng	Promosa	Ikageng
Total number of years teaching experience	Not indicated	3 years	2 years	Not indicated	Not indicated
Participated in focus group interview	√	√	√	X	X

Five senior phase Technology teachers (three males and two females, representative of two cultural-language groups) actively participated in andragogic learning activities and exercises, over a period of three days, intended to stimulate the infusion of Indigenous Knowledge into Technology Education. Table 3.1 reports the general demographical profile of the five

Technology teachers who attended and participated in the 3rd intervention cycles of this qualitative case study investigation.

During the 3rd intervention cycle, qualitative data was collected by means of the following qualitative methods of data collection: (i) teachers' self-reflective sheets, (ii) a focus group interview, (iii) teachers' indigenous technological artefacts, (iv) teachers' collaborative mind maps, and (v) by means of a qualitative open-ended questionnaire. Participants gave me permission to take photographs of them while engaging in the SLP learning activities, and also gave me permission to freely make use of these photographs in the reporting of my research findings. However, it should be noted that I did not take these photographs as a method of collecting qualitative data, and accordingly, I did not include these photographs as part of my integrated qualitative dataset, and no qualitative photographic data analysis was therefore required or performed. Photographs are included in this research report merely to offer the reader visual glimpses of the Senior Phase Technology teachers' active participation in the learning activities of the SLP, and also to visually show some of the artefacts that they created.



Figure 3.7: Photographic evidence of me and the five participants during the 3rd intervention cycle. Photographer: Prof. J. de Beer. Published with the written consent of all the participants.

As outlined in the previous chapter, the 3rd intervention cycle, involved five Technology teachers, who attended a three-day Short Learning Programme in the North West Province, during which Indigenous Knowledge was implemented and used for teachers' continuous professional development with regard to the core content areas in the Senior Phase Technology Curriculum. For one of the learning activities in the short-learning programme, I requested from participants that they collaboratively design and construct an indigenous bridge artefact, using dowel sticks, rope, and glue, in order to solve a community-based problem, sketched out by the following given case scenario, while following the steps of Problem-Based Learning proposed by Havenga (2019):



Open Access Photograph in Public Domain. Source: Moscow Education Association (1908)

People in a local community have to cross a river to get to banks, shops, and medical facilities in the town. Children also need to cross the bridge to go to school and the elderly need to collect their government grants in town. At times this can be dangerous, especially when the water level rises after rains. The closest bridge is far away. Crocodiles have also been spotted in the area. As a result, a bridge should be developed for the community. It must be long enough to allow someone to cross the river safely without needing to walk on the riverbanks (Havenga, 2019).

Figure 3.8: Case study scenario for the application of the design process of designing and making a bridge artefact to solve a community-based problem

Participants were also requested to each complete a teacher self-reflective sheet. At the end of the short learning programme, three of the Technology teachers also participated in a focus group interview, in which I encouraged my participants to openly share their attitudes, needs, challenges, and experiences, with regard to their integration and use of Indigenous Knowledge and skills to attain professional development into the core content areas in the senior phase Technology Curriculum. Furthermore, during the 3rd intervention cycle, in yet another hands-on learning activity, participants collaboratively created a mind-map reflecting their andragogic use of Indigenous Knowledge to explain *food preservation*, as another core content area of the Curriculum.

Five senior phase Technology teachers (three males and two females, representative of two cultural-language groups) actively participated in andragogic learning activities and exercises, over a period of three days, intended to stimulate the infusion of Indigenous Knowledge into Technology Education. Furthermore, during the 3rd intervention cycle, in yet another hands-on learning activity, participants collaboratively created a mind-map reflecting their andragogical use of Indigenous Knowledge to explain *food preservation*, as another core content area of the Curriculum.

In all the three intervention cycles, pre-intervention (*prior to the commencement of the intervention*) and post- intervention questionnaires were administered to participants comparing the knowledge and understanding of participants with regard to indigenous knowledge.

I originally anticipated that at least thirty (n=30) participants would participate in each intervention cycle, taking into account the available sampling pool, consisting of Technology teachers, who taught a compulsory school subject within the Senior Phase of the public South African school curriculum. However, the final available number of participants in this study were N=18 in total, namely n=5 participants in the first intervention cycle, n=8 participants in the 2nd intervention cycle, and n=5 participants in the 3rd intervention cycles. I originally planned to follow a mixed-methods research design, in which I would have collected both qualitative data (as collected in the current study), as well as quantitative empirical data (by administering a quantitative Likert-type of questionnaire developed by Cheng, Kuo, Lin and Lee-Hsieh, (2010) to a larger research sample) over five intervention cycles. However, due to the outbreak of Covid-19, I was restricted to only three intervention cycles, and to only following a qualitative case study research design, due to the limited availability of research participants, social distancing and travelling restrictions implemented during the National lockdown.

3.3.4 Techniques used to prepare, the various sets of qualitative data that were generated through multiple qualitative methods of data collection, for data analysis

Table 3.2 provides the techniques that I used in order to prepare the various sets of qualitative data, which were generated through multiple qualitative methods of data collection, for the purpose of creating a single qualitative dataset on which I perform my qualitative data analysis.

Table 3.2: Techniques that I used to prepare the various sets of qualitative data that were generated through multiple qualitative methods of data collection

Methods Used to Collect Qualitative Data	Various Sets of Qualitative Data that were Generated	Techniques used to prepare the sets of qualitative data for data analysis
Qualitative open-ended questionnaire	Qualitative open-ended questionnaire data	The handwritten responses of participants in reaction to various questionnaire items, were typed over word-for-word and saved into electronic format.
Teachers' self-reflective sheets	Participants' qualitative reflections on their application of the design process in Technology Education, using the various steps of problem-based learning.	Handwritten self-reflection sheets of participants were typed over word-for-word and saved in electronic format
Focus group interview with teacher participants	Participants were interviewed to generate the required data for the study pertaining to their views, perceptions, and experiences regarding the infusion of Indigenous Knowledge into Technology Education	Digital audio recordings were made of the <u>focus</u> group interviews. Verbatim orthographic transcriptions were made of these audio recordings, and saved in electronic format.
Teachers' portfolios,	Only two participants compile and submitted portfolios at the end of the 1 st Intervention Cycle	Participants handed in the portfolios for qualitative data analysis. I qualitatively and purposefully selected aspects of the portfolios, for the purpose to using these to support the main qualitative findings of this study.

Teachers' indigenous technological artefacts	Participants physically constructed bridge artefacts (models) using the design process in Technology Education in order to solve a given problem from the case scenario.	Design and constructional aspects of these artefacts were not further analysed. Submission of these physical bridge artefacts, were considered as qualitative evidence that the participants successfully designed and constructed artefact solutions for the given problem, while applying the steps of the design process and simultaneously infusing Indigenous Knowledge into Technology Education. Photographs were taken of these bridge artefacts and included in the discussion of findings as visual examples of the solutions that participants designed and constructed, without performing any further qualitative photographic analysis of their contents.
Teachers' collaborative mind maps	Participants' collaboratively sketched mind maps showing their infusion of Indigenous Knowledge for the purpose of teaching food preservation and processing in Technology Education.	Participants presented their collaborative mind maps, and I collected these mind maps at the end of the SLP. I took photographs of these mind maps as evidence of participants' successful infusion of Indigenous Knowledge into Technology Education. No further qualitative photographic data analysis was performed with regard to the content of these photographs.

The qualitative data were combined to create a single integrated qualitative dataset, and then a qualitative constant content analysis was conducted on this data.

3.3.5 Creating a Combined Qualitative Integrated Dataset for Qualitative Data Analysis

Using qualitative methods of data collection, I generated a combined integrated qualitative dataset consisting of data collected by means of: (i) a qualitative semi-structured, open-ended questionnaire, (ii) teachers' self-reflective sheets, (iii) a focus group interview, (iv) teachers' indigenous technological artefacts, and (vi) teachers' collaborative mind maps.

3.3.6 Constant Comparative Content Analysis Performed on the Qualitative Data

In order to explain the data to the reader, qualitative data analysis entails creating data categories, typologies, or theoretical formulations. The process of extracting meaning from qualitative data involves looking for recurring regularities in the data (Merriam & Tisdell, 2016, p. 763). I performed a constant comparative content analysis on my integrated qualitative

dataset. The process of constant comparative content analysis is based upon a systematic approach of coding qualitative data. According to Given (2008, p. 85)

"In qualitative research coding is the process of generating ideas and concepts from raw data such as interview transcripts, field notes, archival materials, reports, newspaper articles, and art. The coding process refers to the steps the researcher takes to identify, arrange, and systematize the ideas, concepts, and categories uncovered in the data. Coding consists of identifying potentially interesting events, features, phrases, behaviours, or stages of a process and distinguishing them with labels"

I use the following steps, as recommended by some of the pioneers of qualitative data analysis, Glaser and Strauss (1967), Guba and Lincoln (1981), Merriam (1988), Merriam and Associates (2002), to meticulously perform my constant comparative content analysis on my data:

- (i) **Reading through the dataset to get a holistic overview:** Before starting with my analysis, I read through the entire dataset in order to obtain a holistic overview of my data. While reading through the data, I made preliminary comments in the page margins in order to start identifying incidences of possible findings within the dataset (Merriam and Associates, 2002).
- (ii) **Open coding:** I qualitatively analyzed the transcriptions that I prepared for the purpose of the analysis (as explained in Section 3.3.4 above), sentence by sentence, by coding the data to form initial categories of information related to the research aims of my case study. Through this process I established a primitive system of classification, in order to uncover numerous incidences within the data.
- (iii) **Moulding Categories of Data:** Next, I moulded the classifications, pattern and regularities that I found during the process of open coding, into categories and sub-categories of data, as proposed by Glaser and Strauss (1967).
- (iv) **Axial Coding:** Then I organize my data in new ways, while making connections and establishing meaningful relationships between categories and sub-categories of data, in order to help identify central phenomenon in my data. During Axial coding, conceptually similar incidences in the data were coded, and the relationships between open codes were identified (Blair, 2015, p.18).
- (a) **Selective Coding:** Finally, I identified core data themes within my data to which conglomerations of categories and sub-categories of data belong. These data categories and sub-categories of data, that are based upon a preponderance of data, are internally homogeneous, i.e. unidimensional, and simultaneously externally heterogeneous, i.e. as different as possible from category to category (Guba and Lincoln, 1981). Following Blair (2015, p.18), I used selective coding to further organize my data in order to establish an 'analytic gestalt' (Blair, 2015, p.18) from which a combined hermetic unit of findings was created.
- (v) **Writing up the findings:** The constant comparative content analysis ends with the

reporting of a combined hermetic unit of findings, based upon the meaningful relationships and dynamics that were identified between categories and sub-categories of data, which conglomerated into central themes of data.

- (vi) **Additional Analyses:** In addition to the above analysis, protocol coding was also used to search the integrated dataset for evidence of Self-Directed Learning attributes, as defined by Knowles (1975), while I further analyzed my data using third-generation Cultural-Historical Activity Theory (CHAT) as a research lens.

3.3.7 Research lens: Third-generation Cultural-Historical Activity Theory

I used third generation Cultural-Historical Activity Theory as a research lens through which I analyzed the qualitative findings pertaining to the 2nd Intervention Cycle of my study. According to Tkachenko and Louis (2014), Cultural-Historical Activity Theory (CHAT) is based on the work of developmental psychologists Vygotsky (1978) and Leont'ev (1978) who explored how society relates to the wider cultural and historical context in which they operate. Cultural- Historical Activity Theory (CHAT) has its roots in Vygotskian theory on social constructivism, which emphasizes the role of psychological tools and signs in teaching and learning (Mentz & De Beer, 2019). CHAT takes as starting point that human practice is mediated by tools or signs. CHAT considers human psychological functioning as embedded in a culture and history. The unit of analysis is therefore always the person in context (Havnes, (2010). Cultural-Historical Activity Theory has been chosen as the research lens for this study due to the capacity it holds firstly to provide this research project with the set of epistemological assumptions with which investigate how the Technology Education School Curriculum can be decolonized by the infusion of Indigenous Knowledge (Waitoller & Kozleski, 2013). Secondly the CHAT lens makes provision for a specific gaze into the activity system- looking for an acting subject (the Technology teacher), an object of activity (scaffolding teacher PCK and professional development), tools (artefacts and indigenous knowledge), rules (e.g. the tenets of Technology and the tenets of indigenous knowledge), the community (all the stakeholders involved) and a division of labour (the different roles of the teacher, e.g. a mediator of learning, and critical reflective practitioner) (Mentz & De Beer, 2017) .

As argued by Kakarino (2013), Activity Theory has been framed and advanced around the 1930s by Leontiev and Rubinstein, as an endeavor to regulate contradictions and restrictions of the main streams in psychology during the first decades of the 20th century. In this study, drawing from the work of Joo (2014) Cultural-historical activity theory (CHAT) is applied in order to explore the contradictions in Technology Education to bring about change in the attitude of Technology teachers towards the infusion of Indigenous Knowledge in Technology Education. Similarly, as

suggested by O'Neill (2016), CHAT is an “activist and interventionist” method which is useful in understanding human behavioral change in a culturally mediated context. CHAT is further chosen as the lens because Technology teachers cannot be separated from their ability to engage in self-improvement within their cultural and historical context of the communities from which they operate. Tylor (2014a, p. 96), further adds that “CHAT is appealing because, like other approaches embedded in a dialectical tradition, it aims to understand how to create the conditions for full human development”. The diagram below shows how the affordances of the infusion of Indigenous Knowledge in Technology Education is seen from the viewpoint of the CHAT lens.

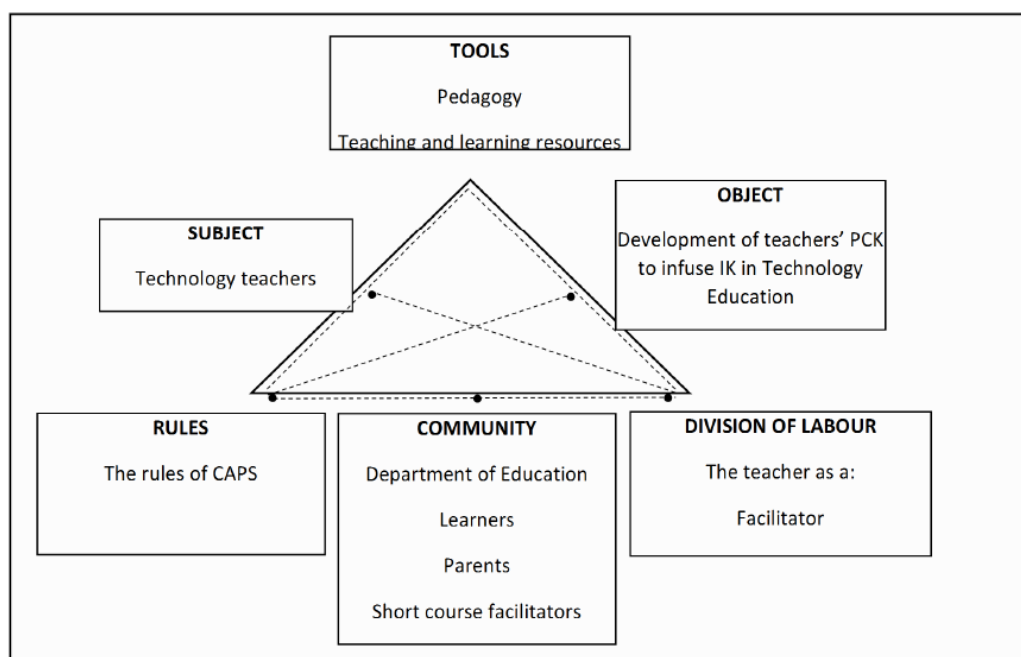


Figure 3.9: The affordances of the infusion of Indigenous Knowledge in Technology Education, as seen from a CHAT lens (Adapted from Kilinc, Chapman, Kelley, Adams, & Millinger, 2016)

In Chapter 4, I will juxtapose, in third-generation CHAT parlance, two activity systems (Engeström, 1987), namely (a) the short learning programme, and (b) the post-intervention Technology classroom (e.g. looking at teachers' lesson plans in the portfolios), to determine whether transfer of new knowledge and skills took place in the classroom regarding the infusion of indigenous knowledge.

3.3.8 Trustworthiness, Credibility and Interrater Reliability of the Qualitative Findings

This qualitative case study was firstly guided by the following standards, as recommended by Eisenhart and Juirow (2013), which contributed towards the general trustworthiness and credibility of my qualitative findings which I inductively derived from my qualitative data analysis:

- Standard 1: I ensured a good fit between the research questions, data collection procedures and data analysis techniques.
- Standard 2: I provided a good context for the study, in order to ensure that the reader of the dissertation will have a good understanding of who the participants were, how the data was collected, and what the features were that characterized the activity system.
- Standard 3: My own assumptions and biases were minimized during the research through triangulations and member checking.

In addition, the reliability and credibility of the qualitative data of my study, as well as the findings based on these data, have been ensured by the following measures that I have taken, as recommended by the guidelines provided by Merriam (2009) and Creswell (2003):

- Only real-life practicing senior phase Technology teachers were invited to participate in the study. All the participants in this study were Senior Phase Technology teachers with the necessary expertise to teach the subject which provided an ideal ground to critically and meaningfully engage in the phenomenon under exploration (Yin, 2011).
- I am a lecturer in Technology Education at North-West University, with 15 years of actual classroom teaching experience in the school subject Technology, which contributed to the data's trustworthiness, based on my experiences, expertise, and experience in Technology Education. Qualitative data was generated until data saturation was reached (Merriam, 2009).
- During the data analysis, a triangulation technique was employed to verify the accuracy of the data analysis and interpretation (Merriam, 2009). During this triangulation, I asked one of my colleagues, who has proficient knowledge and skills in Technology Education and Indigenous Knowledge Systems, to also code and analyze the data. We then compared the findings of our respective analyses with each other, and where the findings significantly differed between the two, we discussed, clarified and resolved such issues through collaborative efforts.
- The use of a recording device (my mobile phone's voice recorder application) assisted me to create word-for-word verbatim transcriptions of the focus-group interview narratives, on which the qualitative data analysis was performed.
- Furthermore, the data generated was examined in an unprejudiced manner and discussed with participants, which included a peer researcher, who is also a Technology Education expert.
- Any unclear data and findings were clarified by follow-up conversations with participants (Merriam, 2009).
- Member checking: The data generated and the findings were presented to the participants in order to assess whether the responses recorded accurately reflect their own views (Maree, 2016).

- Finally, I also triangulated and calculated the interrater reliability for the findings derived from the focus group interview data generated during the 3rd Intervention Cycle, which is fully explained in the section that follows:

Interrater reliability calculated for the findings derived from the focus-group interview data of the 3rd intervention cycle

Cohen's kappa coefficient (κ), introduced by Cohen (1960), is a statistical calculation used in qualitative research to measure the agreement (interrater reliability) between two raters who each classify N items (themes) into k mutually exclusive data categories (McHugh, 2012). In qualitative research Cohen's kappa coefficient (κ) is much more than just a percentage of agreement between two raters/analysts in a study, as κ also takes into account the possibility of agreement occurring by mere chance. Following Cohen (1960), the kappa coefficient (κ) is calculated by the following equation:

$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

Where p_o is the relative degree of agreement observed between the choices made by two (or more) independent raters/judges/experts/data analysts, and p_e is the hypothetical probability of this agreement occurring by mere chance. Similar to correlation coefficients, Cohen's Kappa (κ) can range from -1 to +1, where 0 represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between two raters. While kappa values below 0 are possible, Cohen (1960), however, found this to be unlikely in practice. Table 3.3 shows the interpretation criteria for Kappa (κ) values, as originally suggested by Cohen (1960).

Table 3.3: Interpretation of Kappa (κ) values as suggested by Cohen (1960)

Cohen's Kappa Coefficient Values	Level of Agreement
$K < 0$	No Agreement
$0.00 \leq K \leq 0.20$	None to Slight Agreement
$0.21 \leq K \leq 0.40$	Fair Agreement
$0.41 \leq K \leq 0.60$	Moderate Agreement
$0.61 \leq K \leq 0.80$	Substantial Agreement
$0.81 \leq K \leq 1.00$	Almost Perfect Agreement

The qualitative data, generated during Intervention Cycle 2 of my study, was only thematically analyzed, without any further categorization of the data themes that emerged. Interrater agreement (reliability) could therefore not be calculated for the findings pertaining to the 2nd Intervention cycle. However, the categorical and thematic nature of the findings obtained from the qualitative data analysis performed on the focus-group interview data collected during the 3rd intervention cycle, ideally allowed for the triangulation of these findings by calculating interrater reliability by means of Cohen's Kappa (κ).

Accordingly, I calculated and measured the level of agreement (interrater reliability) between two raters who independently classified $N=11$ categories of data that were identified from the qualitative data analysis performed on the 3rd intervention cycle dataset, into $k=2$ mutually exclusive data categories, as suggested by Landis and Koch (1977), and McHugh (2012). The two raters included myself and one of my colleagues, who is also knowledgeable about Technology Education and Indigenous Knowledge systems. I made use of a web-based statistical GraphPad Software (2020) to capture, in a data-matrix, how the two independent raters classified 11 data categories into two mutually exclusive data themes. Table 3.4, included on the next page, reports satisfactory reliability (substantial interrater agreement) for the findings related to the 3rd intervention cycle, measured by a Cohen Kappa value of (κ) = 0.633, with a 95% confidence interval (CI) that the value of the overall population lies between 0.174 and 1.000. Through this exercise, I statistically confirmed the reliability of the qualitative findings derived from the focus-group interview data obtained during the 3rd intervention cycle.

Table 3.4: Satisfactory reliability (inter-rater agreement), measured by Cohen's Kappa Coefficient (κ), calculated for the qualitative categorical and thematic focus-group interview findings of the 3rd Intervention Cycle

		TWO DATA THEMES	
		Inherent Nature of IK	The Use of IK to Solve Learning Problems in Technology Education
11 DATA CATEGORIES	Indigenous Knowledge is inherent culturally accumulated knowledge, transferred from one generation to the next	RATER 1 RATER 2	
	Indigenous Knowledge provides opportunity for more in-depth teaching and learning		RATER 1 RATER 2
	Collaborative group learning to develop practical solutions for problems		RATER 1 RATER 2
	Social considerations		RATER 1 RATER 2
	Indigenous Knowledge is inherent knowledge that is irreplaceable and non-substitutable	RATER 1 RATER 2	
	Alternative means to collaboratively develop practical solutions for problems		RATER 1 RATER 2
	Indigenous Knowledge is an intrinsic component of learning	RATER 1 RATER 2	
	IK is fundamental knowledge on which future knowledge is built.	RATER 1 RATER 2	
	Repository of accumulated IK, practices and traditions which inform how each community and culture solve particular problems	RATER 2	RATER 1
	Seek IK advice from community members and elders	RATER 2	RATER 1
	Environmental considerations		RATER 1 RATER 2
Number of observed agreements: 9 (81.82% of the observations) Number of agreements expected by chance: 5.5 (50.41% of the observations) Cohen's Kappa Coefficient (κ) = 0.633 – substantial interrater agreement (reliability) Standard Error of Kappa (precision of the estimate) SE = 0.234 Confidence interval (CI) = 95% confident that the value of the overall population lies between 0.174 and 1.000			

3.3.9 Ethical Considerations and Funding

Ethical approval and clearance were obtained from the North-West University's Faculty of Education Sciences Research Ethics Committee, prior to the commencement of my qualitative case study. Provisional generic ethical clearance was obtained under the auspices of the ethical clearance that was previously given in 2016 to the larger NRF-sponsored project (**NWU-00271-16-A2**), under which my thesis was registered, since this qualitative study is part of a larger research initiative funded by the National Research Foundation and the Fuchs Foundation. However, ethical clearance was also obtained for this specific study. This study was classified as "minimal risk" as there was no potential risk to participants, and ethical clearance was issued for my research study (**NWU-00791-18-S2**). Copies of both ethical clearance certificates are included in this report under Addendum A.

In order to avoid any potential harm during the research process, it is very important for researchers to adhere to ethical considerations (Yeasmin & Rahman, 2012). According to Nolen and Van der Putten (2007), in order to avoid any possible ethical issues, it is vital to ensure informed consent, confidentiality and independence of participants during the research project. Participants granted me formal permission and informed consent to use and analyze their data and to report the findings. Participants also gave me permission to take digital photographs of them during the short learning programme, and also to make use of and publish these photographic artefacts as visual evidence to support my qualitative findings. All participants in the study were practicing Technology Education teachers of over 18 years of age with none displaying any compromised mental capability. Prior to the commencement of the short learning programme in each cycle, informed consent was read and obtained from all participants (Addendum B). Participation was voluntarily, and participants were informed about their right to withdraw from the study at any time or stage of the research process. All participants were treated with respect and dignity, and their rights were protected. Assistance was available during all three intervention cycles, and participants gave me permission to take photographs of them actively participating in the learning activities of the SLP, and also gave me permission to make use and publish these photographs as part of my research reporting of findings.

3.4 Summary of Chapter Three

In this chapter I explained how the two research components of my qualitative case study are anchored within the Constructivist and Interpretivist research paradigms. Next, the qualitative case study research design and methods of data collection were discussed. The chapter then continued to provide a comprehensive outline of the three intervention cycles that I implemented as part of the Designed-Based Research approach that I followed. The chapter furthermore

provided the necessary information with regard to the research sample, and the demographical information of participants.

The chapter also explained the techniques that I used in order to prepare the various sets of qualitative data, and also how these sets of qualitative data were combined into a single integrated qualitative dataset, and consequently, the chapter goes on to explain the steps I took and procedures I followed, in order to perform a constant comparative content analysis on my combined qualitative dataset. Accordingly, the qualitative findings gained from this qualitative constant comparative content analysis, are reported, interpreted and discussed in Chapter 4 that follows.

Chapter 4

Discussion of the qualitative findings generated from the three intervention cycles

Mofufutso, go jewa wa phatla; wa segarwe ga o jewe

(It is the sweat of one's forehead that is eaten; not the sweat of one's seat)

Chapter 4

Discussion of the Qualitative findings generated from the three intervention cycles

4.1. Introduction

As indicated in Chapter 1, a short-learning program pertaining to the infusion of Indigenous Knowledge into Technology Education had been delivered to small groups of Senior Technology teachers during three intervention cycles. As explained in the previous chapter, I made use of various qualitative methods of data collection, i.e. by means of: (i) a qualitative semi-structured, open-ended questionnaire, (ii) teachers' self-reflective sheets, (iii) a focus group interview, (iv) photographic evidence, (v) teachers' indigenous technological artefacts, as well as (vi) teachers' collaborative mind maps, in order to generate an integrated qualitative dataset. I performed a qualitative data analyses on my rich integrated dataset, in order to code, 109tilized and group my qualitative data into various interrelated categories and sub-categories of data, which converged into a number of data themes. Accordingly, these thematic and categorical findings are reported in this chapter, in order to find answers to my research sub-questions that were identified in the first chapter of this research report.

4.2 QUALITATIVE FINDINGS FROM THE 1ST INTERVENTION CYCLE: POTCHEFSTROOM, NORTH-WEST PROVINCE

Table 4.1 (on the next page) provides the reflections and thoughts of participants with regard to the steps of problem-based learning (i.e. conceptualization, discussion of the problem context, identification of knowledge and needs, formulation of learning objectives, investigation, and design and development), while applying the design process in order to construct a bridge artefact and simultaneously acquiring Indigenous Knowledge and skills. Qualitative data analysis conducted on the reflections and thoughts of participants with regard to the steps of problem-based learning (used as data themes for the purpose of the qualitative data analysis), revealed various categories of data pertaining to each of the themes of problem-based learning.

Table 4.1: The reflections and thoughts of participants in the 1st intervention cycle on the steps of problem-based learning during the design process of constructing a bridge artefact using Indigenous Knowledge and skills

	Conceptualise	Discuss the problem context	Identify knowledge and needs	Formulate learning objectives	Investigate	Design and develop e.g. the technological process applied in IK.	Assess
Participant 1	At first I had no clue but after engagement with the lecturer and the group it became clearer. The conceptualizing stage stimulates creativity and creative thinking skills. The infusion of humanity and culture in teaching and learning of technology... it's so mind blowing.	This step assists with gathering as much as possible knowledge to resolve the problem that exist in cultural contexts. This process highlights the problem wholeheartedly and one will be able to come up with solutions to the problem and what Resources will be needed to resolve the problem.	Once knowledge and needs are identified, then the planning phase will kick in such that before one could start with the project on key areas for the success of the project will be taken into account.	At this stage of the prerequisite information learning will be known, thus it's going to be easier to formulating learning objectives that one directly linked to the problem that needs to Be refined, at this stage on will be able to respond to the following key questions: What? When? [and] How?	At this stage one will be able to acquire appropriate resources and because they will assist in making informed decisions. At this stage individuals working on this project will be used to interview community members so as to get firsthand information.	These steps will assist one with following ideas into the basket and evaluate each one of them in terms of advantages and Disadvantages. The group or individuals will be able to critically reflect and... [make] ... changes where possible.	Determine each member as well as the groups' contribution towards the problem-based task and learning Gains. Determine whether development of the artefact addressed the problem Of inquiry This step will assist with ascertaining individual And group Contributions towards Completion of the model or the project and further evaluate the finished product whether it will address the problem as expected.
Participant 2	Educator make use of own knowledge with regards to IK, also test if learners have any prior knowledge with regards to IK, refers to the past and how people were living and compare it with our present life and get learners to Think critically on how our future will be.	Learners must be able to identify a problem, either in a classroom situation, on the school premises or either in a community... by getting learners engaged into identifying a problem, they interact Constructively and...	In the process of problem-based learning, learners need to identify the problem and also come up with a solution. The solution must be based on knowledge (what learners already know) and how to apply it with consideration...[to be	When working on the design certain aspects must be kept in mind by learners e.g. safety, environmentally friendly, the cost, durability etc.	Gain more knowledge on research via the community, the use of books on how problem solving phase is going to take place.	During the making process the design should be constantly tested for the purpose intended, for its strength and Durability.	Determine each member as well as the group's contribution towards the problem-based task and learning Gains. Determine whether development of the artefact addressed the problem of inquiry. Each member of the group was actively involved in identifying

	Conceptualise	Discuss the problem context	Identify knowledge and needs	Formulate learning objectives	Investigate	Design and develop e.g. the technological process applied in IK.	Assess
		[it] ...promotes group work.	Of] ...help, and not... harm[full to the environment].				The solution. Everyone input was welcomed and much needed, and nobody's creativity and ideas was treated as on solution, however every member of the group shared accountability and responsibility
Participant 3	Technology should not be treated as an isolated subject. It is a subject that is practical and the community can benefit from it. The subject has a few steps that need to be followed but I believe that is very flexible. We can learn from it and the way people in the past used it to satisfy their needs. The impact of technology can be positive and negative.	People are on the one side of the river and need to cross the river for essential need. This is dangerous because during the rainy season the river over flows and there is also a problem of dangerous animals. In the river and this with all this going on they still have to cross the river for this reason this people needs a bridge to cross the river safely.	The community must go to school walk and see the doctor, by doing this they have to cross the river by feet and it is way dangerous the bridge should be stiff stable and strong that it is safe for the community they use it on a daily basis. The material they use to build the bridge should not harm the environment and should be cost effective.	The bridge must solve the problem they have in the community It has to be strong stiff and stable It must not sway because the learners and old people can get hurt, it should also be wide enough for the cars and trucks to cross If the bridge ideas do not serve its purpose it should be reevaluated.	Find out what is the need	This is a problem based task as it gives a solution to the problem. This process gives you chance to come up with few solutions and then choose the best plan to solve this problem. As we said you have a plan but during this process changes can be made as the technology process is very flexible.	Determine each member as well as the groups' contribution towards the problem-based task and learning gains. Determine whether development of the artefact addressed the problem of inquiry Give groups members specific tasks, this will ease the task each member and save you a lot of time, and the group will meet their deadlines, communication in this regard is vital.
Participant 4	There has been increased interest of drawing upon the Indigenous Knowledge when we tackling the project. Some of our colleagues were not acclimatized by the use of IKS in their school, by	We were given a scenario where we had to solve a problem faced by people of kwa Nogawu. Step by step we engaged in problem solving of the problem faced in the scenario. The impact	Indigenous Knowledge and sophisticated knowledge were used to meet our needs and wants. People kwa Nogawu needed a bridge to cross during rainy season, so safety and lives of people	Professor Benjamin Bloom proposed three learning objectives in his taxonomy for learning. Knowledge capability task and resources task were emphasized in our ALP and they help us to	After gathering information... ...methods were implemented to solve the problem, we used a questionnaire to find out how people of Kwa Nogawu survived during rainy seasons.	I will design and make a stable, safe and strong bridge for people of Kwa Nogawu. New learning activities and the creating of try own learning materials help me to enhance on linking prior knowledge to knowledge	Determine each member as well as the groups' contribution towards the problem-based task and learning gains. Determine whether development of the artefact

	Conceptualise	Discuss the problem context	Identify knowledge and needs	Formulate learning objectives	Investigate	Design and develop e.g. the technological process applied in IK.	Assess
	the help of our lecture, it makes it easier for them and I to get with time course.	of the problem account to the community. After Finding the solution how to tackle the problem. We engage in problem solving by using cooperative learning skills.	were in stake. So we engaged the elderly people to share with us how methods and knowledge they use during rainy season. More and explanations were given to us to Tackle the problem or to solve their problem.	recognize in our various schools. I will identify the level of knowledge want in front. I will also add The criteria to indicate how or whether outcome will be observed to add to the Context. After gathering information, various Methods were implemented to solve the problem... we used a questionnaire to find out how people of Kwa Nogawu survived during rainy seasons. We also use knowledge of elderly people to investigate which materials and machinery will be needed to build the bridge.	We also use knowledge of elderly people to investigate which materials and machinery will be needed to build the bridge.	we gathered in design and developing a solution for our problem. The structure or bridge should cater both elderly and young kids to cross safely To other side of the river.	addressed the problem of inquiry Our group members were full of energy in compiling the information and Building the bridge and cooperative skills were attained on solving People's problem by building a strong and stable bridge.
Participant 5	Technology cannot stand alone it is a subject that has an interrelationship between community, environment It is a practical subject that cater to fulfill the communities or individual needs.	In this village people stay far of the river from the city. They cross the river everyday but during rainy season the river overflow, they also have seen crocodiles and they are afraid to Lose their lives,	The community people must go to school, work, shops on daily basis to accomplish basic needs, they do that by crossing the bridge by their feet, because the town is on the other side. The bridge must be strong, stable, safe	The bridge must solve the village's problem The bridge has to be strong and high enough to carry people Bridge must strong enough to withstand Floods Bridge must be strong so that it must not	We needed to find out what the need in the community was. There was an existing bridge but it did not meet the need. We also develop opinions and at the end we will determine the bridge that will be fit for purpose	This process is important because it structure the Whole problem-based task in that will deliver the solution to the problem During the design process one draw a few ideas to solve the problem and chose the best one will in the end cater to solve the	Determine each member as well as the groups' contribution towards the problem-based task and learning gains. Determine whether development of the artefact addressed the problem of inquiry

	Conceptualise	Discuss the problem context	Identify knowledge and needs	Formulate learning objectives	Investigate	Design and develop e.g. the technological process applied in IK.	Assess
	It has a step by step process that needs to be followed but it is flexible and cannot be used in isolation. We can learn how indigenous culture used specific materials to satisfy their needs. The impact technology has on the lives of the people can be positive or negative. It is also that some groups might be favored or disadvantages by products of technology.	Because they cross the river by foot. They maybe have made use of tree stumps but it is not safe or stable. They are a bridge but it is too far away from them. The village people need a bridge that is closed to them it must be strong and stable and withstand floods during the rainy season. The material that is used to build the bridge must be environmental friendly.	And wide enough for all members to use on daily basis. So there must be some kind of mechanism to easily get access to the bridge like maybe stairs or ramp etc. The materials used to build the bridge must be environmental friendly must not endanger animal or planet lives in the river. The use of concrete blocks to stable the steal poles that will be used to a given height to the bridge and non-slippery wooden surface to walk on	sway and cause people to fall in the river when they walk across. The structure must span over the wide river. If the drawings do not meet the requirements we must adopt it until they do.	We also tested the strait of the bridge and it pass the test, it could carry or hold 2 kg weight.	Problem in all best wrap. While building the model changes are made and one needs to go back to the drawing board to make this adjustment. Also members are made known of the safer working practices skills are increasing, better organizing, the suitability and purpose of the material, the impact the model will have towards the environment It is also important that one needs to work in an workshop and safety work practices must apply.	It is important that all the group members know from the start what their role will be and that they complete their part to the best of their ability. This will safe time, less waste of resources and the effective working or completing of the model in time. So communication is thus vital, it is happening on an ongoing basis, we record, present the progress in written, graphical and verbal form. Each group member also see than the value that he/she has contributed in solving the problem successfully. Our task was to design a bridge make up out of recycle material for village people to cross safely to the other side of town. Our group I think successfully completed the task at hand.

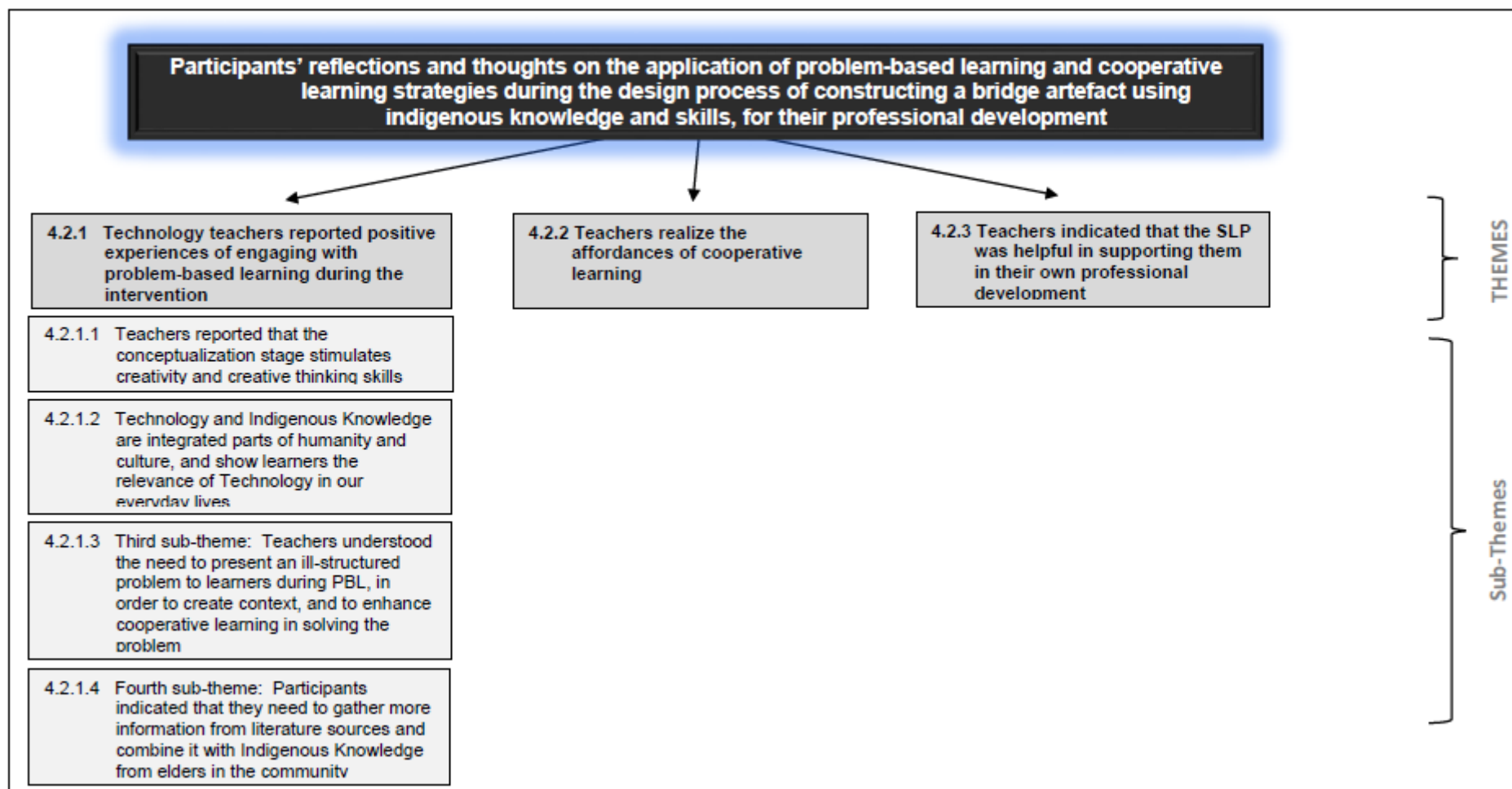


Figure 4.1: Data themes and sub-themes that emerged from participants' reflections and thoughts on the application of problem-based learning and cooperative learning strategies during the design process of constructing a bridge artefact using Indigenous Knowledge and skills, for their professional development

Figure 4.1 shows the themes and sub-themes that emerged from the participants' reflections and thoughts on the application of problem-based learning and cooperative learning strategies during the design process of constructing a bridge artefact using Indigenous Knowledge and skills, for their professional development. These themes and sub-themes are discussed in the sections that follow:

4.2.1 Theme 1: Technology teachers reported positive experiences of engaging with problem-based learning during the intervention

During the application of problem-based learning strategy, Technology teachers reported positive experiences of engaging with problem-based learning during the intervention. This first theme has three related sub-themes:

4.2.1.1 First sub-theme: Teachers reported that the conceptualization stage stimulates creativity and creative thinking skills.

For Participant 1, conceptualization stage:

“...stimulates creativity and creative thinking skills”.

4.2.1.2 Second sub-theme: Technology and Indigenous Knowledge are integrated parts of humanity and culture, and show learners the relevance of Technology in our everyday lives

Participants conceptualized Technology and Indigenous Knowledge as integrated parts of humanity and culture. In the words of Participant 1:

“The infusion of humanity and culture in teaching and learning of technology... it's so mind blowing.

Participant 5 also commented:

“Technology cannot stand alone it is a subject that has an interrelationship between community... [and the] ...environment”

According to Participant 5, Technology

“...is a practical subject that cater to fulfill the communities or individual needs. ...The impact of technology can be positive and negative”.

Participants acknowledged the value of Indigenous Knowledge in the Technology classroom. Participant 1 explained that:

“Educator make use of own knowledge with regards to IK, also test if learners have any prior knowledge with regards to IK, refers to the past and how people were living and compare it with our present life and get learners to think critically on how our future will be”.

Participant 5 furthermore remarked:

“We can learn from it and the way people in the past used it to satisfy their needs”.

4.2.1.3 Third sub-theme: Teachers understood the need to present an ill-structured problem to learners during PBL, in order to create context, and to enhance cooperative learning in solving the problem

Participant 2 wrote:

“Learners must be able to identify a problem, either in a classroom situation, on the school premises or either in a community... by getting learners engaged into identifying a problem, they interact constructively and... [it] ...promotes group work”.

Participants indicated that learners need to cooperatively gather sufficient information on how to solve the problem using Indigenous Knowledge and Skills. Participant 1 remarked:

“.... Gathering as much as possible knowledge to resolve the problem that exist in cultural contexts”.

Participants also indicated that they understood that learners need to identify the problem, then cooperatively find a solution based on what is needed to address the problem, while taking environmental and social factors into consideration. For example, Participant 2 commented:

“In the process of problem-based learning, learners need to identify the problem and also come up with a solution. The solution must be based on knowledge (what learners already know) and how to apply it with consideration... [to be of] ...help, and not... harmful to the environment”.

4.2.1.4 Fourth sub-theme: Participants indicated that they need to gather more information from literature sources and combine it with Indigenous Knowledge from elders in the community

During the investigation step of problem-based learning, Participant 4 indicated that more information is gathered from literature, combined with Indigenous Knowledge gained from elders in the community, on how to solve the problem:

“we used a questionnaire to find out how people of Kwa Nogawu survived during rainy seasons. We also use knowledge of elderly people to investigate which materials and machinery will be needed to build the bridge”.

4.2.2 Theme 2: Teachers realize the affordances of cooperative learning

Participants realized the affordances of cooperative learning. Participant 4 explained:

“Determine each member as well as the groups’ contribution towards the problem-based task and learning gains. Determine whether development of the artefact addressed the problem of inquiry... Our group members were full of energy in compiling the information and building the bridge and cooperative skills were attained on solving people’s problem by building a strong and stable bridge”.

Participants also indicated that they are skilled in the utilization of cooperative learning techniques. In the words of Participant 4:

“Determine each member as well as the groups’ contribution towards the problem-based task and learning gains. Determine whether development of the artefact addressed the problem of inquiry... Give group members specific tasks, this will ease the task each member and save you a lot of time, and the group will meet their deadlines, communication in this regard is vital”.

4.2.3 Theme 3: Teachers indicated that the SLP was helpful in supporting them in their own professional development

Participants also indicated that they found the SLP helpful in incorporating Indigenous Knowledge in their Technology lessons. Participant 4 explained that:

“After gathering information, various methods were implemented to solve the problem... We used a questionnaire to find out how people of Kwa Nogawu survived during rainy seasons. We also use knowledge of elderly people to investigate which materials and machinery will be needed to build the bridge”.

4.3 QUALITATIVE FINDINGS FROM THE 2ND INTERVENTION CYCLE: NAMAQUA DISTRICT, NORTHERN CAPE PROVINCE

The following themes emerged from the qualitative analysis of the data collected during the 2nd intervention cycle:

4.3.1 Theme 1: Teachers benefited from the SLP, and also indicated the need for continuous in-service teacher professional development

Technology teachers indicated that in-service training is necessary for integrating Indigenous Knowledge into the technology classroom. While the DBE encourages teachers to infuse Indigenous Knowledge into their classrooms, the CAPS document does not specify how to accomplish the task (De Beer, 2016). The lack of training left many teachers frustrated with the task of integrating indigenous knowledge. Therefore, teachers welcomed this SLP, and indicated that it greatly assisted them in their professional development to engage in such epistemological border-crossing in the classroom. They also suggested that more such interventions are needed.

In responding to the in-service training needs of Technology teachers, one participant reported:

"I really enjoyed the course and I really feel capacitated, I believe if done correctly the design process included in the three task type for technology teaching makes it easier for learners to engage and draw from their parents..."

"It was really fantastic, the facilitators made their presentation lively and relevant..."

These findings are consistent with the study conducted by Cronje et al. (2015), who reported an increase in interest and capacity of teachers when attending professional teacher development opportunities. Bernstein (2011) indicated that once-off workshops are not sufficient, and that longitudinal teacher professional development (within communities of practice) are needed. This was echoed by the participants in this study.

4.3.2 Theme 2: Teachers expressed the need for continuous PCK development

Participants furthermore expressed their need for continuous PCK development. In the words of Participant A:

“You know I have been avoiding to begin my lessons with case studies as I considered them a waste of time, now I realise their importance... I see now that that can be used as a base to assist in the resource task... When my learners do PAT [Practical Assessment Task], they can see how the content is aligned...”

4.3.3 Theme 3: The need for structured support

Northern Cape is South Africa's most sparsely populated province. The Namakwa district is comprised of rural schools located on average, 200 kilometers apart. This distance and limited internet connectivity confounded the establishment of a Technology teachers' community of practice. Lave and Wenger (1991) define a community of practice as a group of people with common interests coming together to share knowledge and improve their practice. During the SLP, teachers commented on the lack of connection, and emphasized the need for support, in order to apply the professional development training in their classrooms. Teacher B stated:

“I sometimes feel isolated in my classroom, as I do not have other teachers who can mentor me. Sometimes you just need a colleague who can critique your lessons”.

Technology teachers indicated a need for school level support. Two thirds of the teachers indicated that they were not qualified to teach the subject area. They stated that many schools do not have a qualified technology teacher, instead teachers in other subject areas were recruited to teach technology. In addition to the lack of specialized training and content knowledge, teachers reported that the school schedule did not allow time for reflection on classroom practice. Teachers reported being overwhelmed with CAPS requirements that demand the majority of their focus and time. Technology teachers indicated that more often than not their focus is on completing the work prescribed for the term and little time is afforded for infusing indigenous knowledge.

Two of eight participants submitted the portfolio required to complete the course. This could indicate the need for supportive follow-up interventions and guidance on how to complete the portfolio tasks.

4.3.4 Theme 4: Transfer to the classroom: a mixed-bag

One of the Technology teachers submitted an excellent portfolio, whereas the second portfolio provided evidence of chalk-and-talk approaches, and only provided 'lip-service' to indigenous knowledge, despite the intervention. From the latter portfolio, it was clear that systemic factors (e.g. timeframes provided by the Department of Education) often result in teachers abandoning inquiry approaches favouring the technology design process, in favour of

transmission-mode teaching.



Figure 4.2: This photograph was included in a Technology teacher's portfolio as evidence of learners engaging in the technology design process during a post-intervention class in which the teacher applied the knowledge and skills gained through the short learning programme. Here the learners tested the strength of their constructed bridge.

Based on the aforementioned themes, senior phase Technology teachers recognized their need for in-service training, pedagogical content knowledge development and structured support to effectively implement appropriate teaching strategies and integrate Indigenous Knowledge in their technology classrooms. The findings illustrate that Technology teachers face challenges transferring knowledge gained in the short learning programme to their classrooms.

4.4 QUALITATIVE FINDINGS FROM THE 3RD INTERVENTION CYCLE: DR. KENNETH KAUNDA DISTRICT, NORTH-WEST PROVINCE

4.4.1 Additional demographical information of participants in the 3rd Intervention Cycle

In addition to the basic demographic information already provided in Chapter 3, Table 4.2 provides additional demographic information on school subjects taught by teachers who participated in the 3rd Intervention Cycle, on their school infrastructure and resources, on their teaching experience and on their teaching qualifications for Senior Technology Education. .

Table 4.2: School subjects, infrastructure, resources, teaching experience and Senior Phase Technology qualifications of participants who completed the qualitative questionnaire after participating in intervention cycle 3

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
SCHOOL SUBJECTS TEACHING					
Technology (Senior Phase, Grade 7 – 9)	✓	✓	✓	✓	✓
FET subjects		✓		✓	✓
Natural Sciences (Grade 7 – 9)					
Mathematics Intermediate Phase (Grade 6 – 8)					
Mathematics Senior Phase (Grade 7 – 9)					
Other (please specify)	✓ Afrikaans FAL (Grade 8)	✓ Business Studies (Grade 10)	✓ Consumers Studies (Grade 10-11)	✓ Life Orientation (Grade 9)	Not Indicated
SCHOOL GEOGRAPHICS					
Urban					
Township	✓	✓	✓	✓	✓
Rural					
SCHOOL INFRASTRUCTURE AND AVAILABILITY OF RESOURCES					
Does the school have good resources?	X	X	X	X	X

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
Do you have a Technology workshop?	X	X	X	X	X
Is it possible for a teacher to facilitate practical work without a Technology workshop or laboratory? Motivate your answer.	Yes. Rearrange the furniture in such a way that it will be conducive while doing practicals.	Sometimes it is possible because learners bring everything they need at home.	It is difficult because safety measurements must be considered... and the resources available, [as well as]... the amount of learners in class.	Yes I turn my class into workshop by bringing material to be used during lesson presentation	It is extremely difficult to do the practicals and safety issues are not observed.
Do you have access to the internet (either via computer or smart phone)?	√	X	√	√	X
How do you use ICT's (and simulation software) in your teaching?	Do not use	I know how to use the ICT but our schools does not have the resources.	At our school we don't have access to Internet or smartboards.	By linking a real life	I never used ICT in teaching technology.
Do you have access to the library?	X	X	X	X	√
TEACHING EXPERIENCE AND PROFESSIONAL QUALIFICATION IN SENIOR PHASE TECHNOLOGY EDUCATION					
Are you professionally qualified to teach senior phase Technology	√	X	√	√	X
Total number of years teaching experience	Not indicated	3 years	4 years	Not indicated	Not indicated
How long have you been teaching technology	3 years	1 year	2 years	15 years	Not indicated

4.4.1.1 School subjects taught by participants

All five participants indicated that they are responsible for the teaching of Senior Phase (Grades 7 to 9) Technology Education. Participants 2, 4 and 5 also indicated that they teach FET subjects. None of the five participants are teaching Natural Science or Mathematics

subjects. Participant 1 indicated that she is also responsible for Afrikaans FAL (Grade8), Participant 2 also teaches Business Studies (Grade 10), Participant 3 teaches Consumer Studies (Grades 10 and 11), Participant 4 is also responsible for Life Orientation (Grade 9), while Participant 5 did not indicate any other subject that she is teaching besides Senior Phase (Grades 7 to 9) Technology Education and FET subjects. If one considers the diversity of other school subjects that the participants teach, together with other findings reported below, with specific reference to the fact that two of the five participants who are teaching Senior Phase Technology are not professionally qualified to teach the subject, one could assume that these two participants are originally from Business Studies and other FET subjects, and that Technology Education was allocated to them by their schools, due to a lack in qualified Technology teachers. It's also possible that one or two of the three participants who are technically trained to teach Senior Phase Technology came from a different school subject and, since Technology Education was assigned to them, decided to take on the task of professionally qualifying themselves for this new challenge.

4.4.1.2 Geographical information of schools where participants are teaching

All five participants indicated that they are serving Township schools. Three participants are teaching at schools in the Promosa Township, while two are teaching at schools in the Ikageng Townships. Both Townships are situated in the Tlokwe Municipality of the Dr. Kenneth Kaunda District in the North-West Province.

4.4.1.3 School infrastructure and availability of resources

All five participants indicated that their schools lack good resources and Technology workshops. Consequently, teachers are forced to turn their normal classrooms into Technology workshops, in order to facilitate the practical work that is required for the teaching and learning of Technology Education. In the words of Participant 1:

“[We]...rearrange the furniture in such a way that it will be conducive while doing practicals”

While Participant 4 commented:

“I turn my class into workshop by bringing [the] material to be used during lesson presentation”

It seems that teachers are not only forced to supply the required materials to successfully execute practical work in Technology Education (as mentioned by Participant 4), but also have to revert to the practice of asking learners to bring their own materials to class, as mentioned by Participant 2:

“...learners bring everything they need from home”.

However, requiring learners to supply their own materials for practical work is not a viable option since a significant number of South African learners come from low-income families who cannot afford to provide materials for their children’s practical classes, although expecting learners to supply their own materials is not a viable option. This will result in the violation of the human rights of South African children to receive free and equal basic education, as promised by Section. 29(1) (a) of our Constitution (Republic of South Africa, 1996).

Two participants (Participants 1 and 4 as mentioned above) responded optimistically that it is possible for teachers to facilitate practical work without a Technology Workshop or a laboratory, whereas Participant 2 (quoted above) indicated that it is only sometimes possible to do so, depending on whether or not learners supply the materials they need for practical work.. The remaining two participants were skeptical about whether it is possible for teachers to facilitate practical work without a Technology workshop or laboratory, and raised their concerns about safety measurements that are not properly being taken into consideration, as well as the feasibility of facilitating practical work to classes consisting of large numbers of learners. Participant 3 remarked:

“It is difficult because safety measurements must be considered... and the resources available... [as well as] the amount of learners in class”.

While Participant 5 resounded that:

“It is extremely difficult to do the practicals and safety issues are not observed”.

In response to the question as to whether or not participants have access to the Internet (either via computer or smart phone), only 3 participants indicated that they do have Internet access, while two indicated that they do not have access to the Internet at all.

When Participants were asked about the way they make use of Information Communication Technologies (ICTs) and simulation software in their teaching, Participants 1 and 5 indicated that they do not make use of ICTs and simulation software. In the words of Participant 5:

“I never used ICT in teaching technology”.

Only Participant 5 indicated that he has access to a library, while the other four indicated that they do not have access to a library.

4.4.1.4 Teaching experience and professional qualification to teach Senior Phase Technology

Three out of the five participants indicated that they are professionally qualified to teach senior phase Technology. Participant 2 reported a total number of three years of teaching experience, of which one year he has been teaching Technology. Participant 3 indicated a total number of 4 years of teaching experience, of which two years he is teaching Technology Education. It is unclear why the other three participants did not indicate their total number of years of teaching experience. However, Participant 1 indicated that she has three years of experience teaching Technology, while Participant 4 indicated that she has been teaching Technology for 15 years. Only Participant 5 did not indicate for how long he has been teaching Technology Education.

4.4.2 Qualitative findings from the focus-group interview

From my qualitative data analysis of the focus-group interview data, I identified various interrelated categories and sub-categories of data, from which two data themes crystallised:

4.4.2.1 Data Theme 1: Teachers' viewpoints on indigenous knowledge

Figure 4.3 illustrates the categories of data that emerged from my qualitative data analysis pertaining to the first data theme which relates to Technology teachers' viewpoints on the inherent nature of Indigenous Knowledge. These categories of data are:

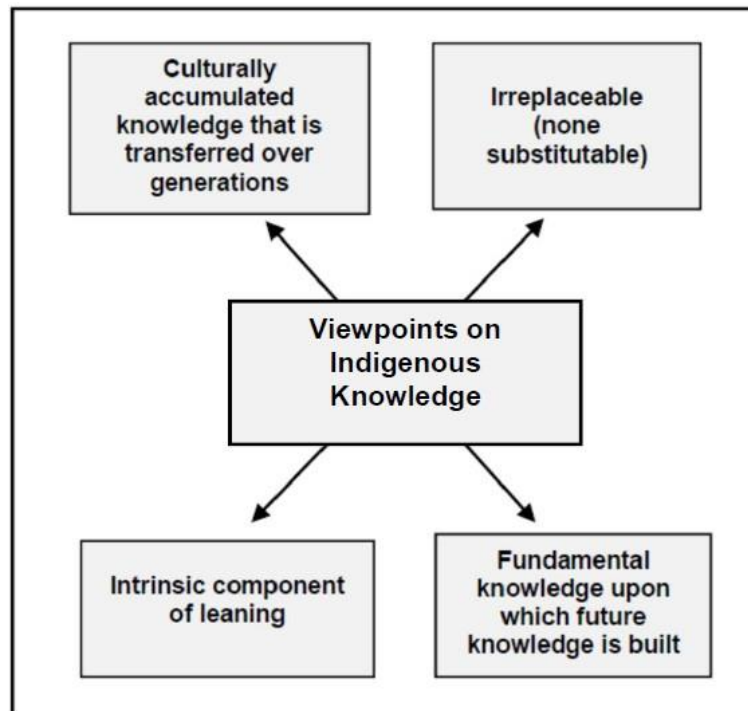


Figure 4.3: Categories of data that emerged from my qualitative data analysis pertaining to Technology teachers' attitudes and viewpoints on Indigenous Knowledge.

Indigenous Knowledge is inherent culturally accumulated knowledge, transferred from one generation to the next

The group of Technology teachers who participated in my case study agreed that Indigenous Knowledge represents inherent culturally accumulated knowledge, traditions, beliefs, and practices that are culturally transferred from one generation to the next. Participant 1 explained that Indigenous Knowledge:

"is important because indigenous is what [we] learnt at home, and when we come to apply it in school we go deeper"

While Participant 3 passionately remarked that:

"the infusion of humanity and culture in teaching and learning of technology... [is] mind-blowing".

The viewpoints of my participants underscore Gumbo's (2015, p. 61) assertion that technology is "*inherently cultural*", as the design and development of artefacts, for example, reflect cultural beliefs.

Indigenous Knowledge is an intrinsic component of learning

Participants alluded to Indigenous Knowledge as an intrinsic component of learning. In the words of Participants 2 and 5, respectably:

"...we needed those Indigenous Knowledge in order for us to be able to build the bridges. We needed that in order to move forward to where we stand today".

"We also use knowledge of the elderly people to investigate"

Indigenous Knowledge is inherent knowledge that is irreplaceable and non-substitutable

The participating teachers agreed that Indigenous Knowledge is inherent knowledge that is important, for it is irreplaceable. Participant 4 elaborated that:

"...Indigenous Knowledge is irreplaceable, we cannot substitute it, so all we can do is to work with it... and built on it... and never throw it away, because we will be throwing away important knowledge".

The integration of African indigenous technological perspectives with Western technological perspectives for the teaching and learning of Technology Education

Furthermore, participating teachers shared their eagerness and intention to combine African indigenous technical perspectives with Western technological perspectives for senior phase Technology Education teaching and learning. Participant 4 argued that:

"...our setup now is Eurocentric. It is nice to be in that setup but, but we should not forget where we coming from, because there were ways of dealing with technological aspects in our old ways... were we coming from.... Yes, it might be nice in the 21st Century, but not everything here is better than were we coming from. So, therefore... given our background... how we used to do things in the past... we can bring that... and see how best can we match the two... [the] old days methods and Eurocentric methods... to make things work for us".

Gumbo (2015, p. 70) shares the same vision as my participants , i.e. to harness both Western and Indigenous technological perspectives for culturally responsive Technology Education, are characterized by: (i) the development of "open-minded" learners who can responsibly apply relevant technologies in particular local contexts; (ii) technological content knowledge that embrace values, designs, materials and applications with the aim to enrich people's lives; (iii) learning support materials that incorporate textbooks, relevant resources, and "techno-labs" for the understanding and manufacturing of both Western and indigenous technological artefacts; (iv) the use of pedagogical approaches that are "invitational" to all learners, where they actively engage with community members and the elders regarding the design and development of products; and (v) the use of "context sensitive" assessment that assist learners to be skillful and professional in their field of study.

4.4.2.2 Second Theme: Technology teachers' design and construction of Indigenous technological artefacts to solve community-based problems in Technology Education

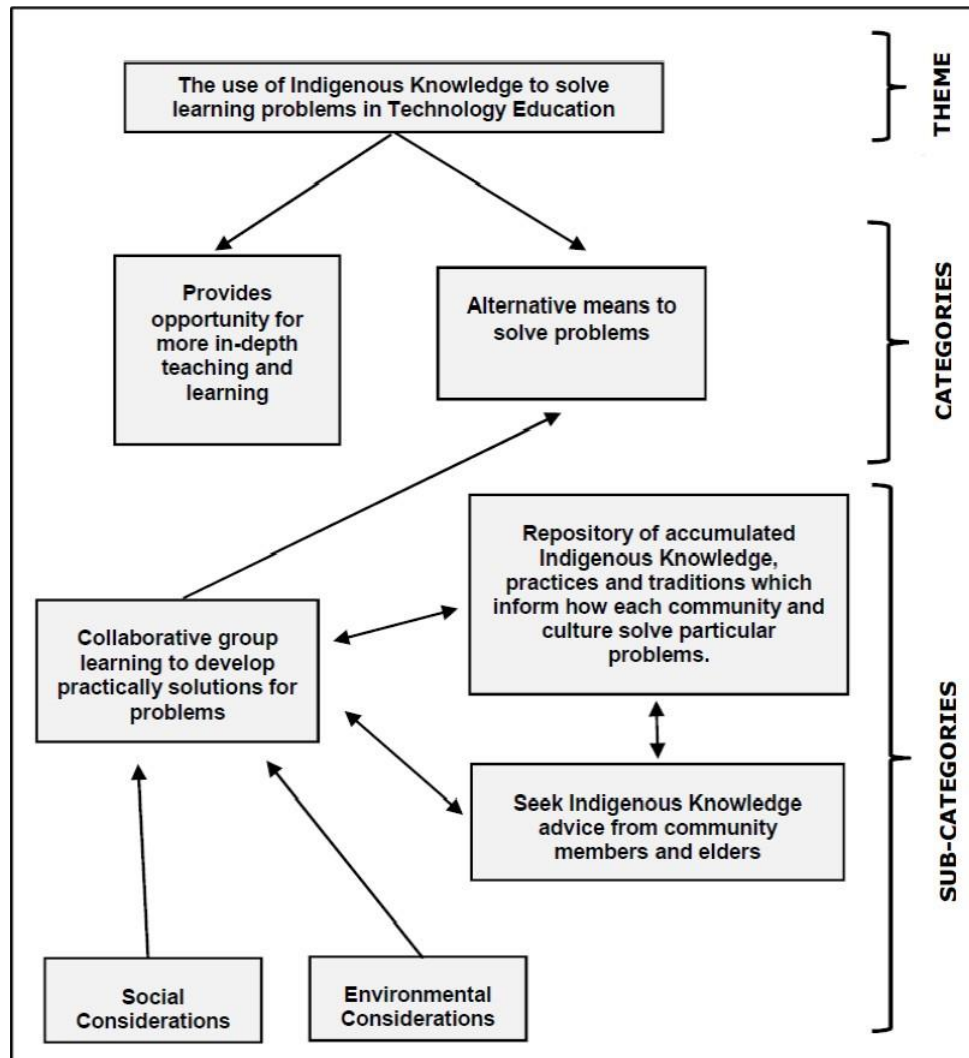


Figure 4.4: Categories and sub-categories of data that emerged from my qualitative analysis pertaining to the second data theme: Technology teachers' design and construction of Indigenous technological artefacts to solve community-based learning problems in Technology Education

Figure 4.4 provides a visual representation of the interrelated categorical findings, which conglomerated into the second data theme that relates to Technology teachers' design and construction of Indigenous technological artefacts to solve community-based problems in Technology Education.

Indigenous Knowledge provides opportunity for more in-depth teaching and learning

According to Participant 1, the pedagogical use of Indigenous Knowledge provides opportunity for more in-depth teaching and learning in Technology Education:

"It is important because indigenous is what we learnt at home, and [when] we come to apply it in school, we go deeper... Ons delf net dieper in dit, nie net oppervlakkig nie [Translates from Afrikaans as: We delve only deeper into it, not only superficially]."

Alternative means to collaboratively develop practical solutions for problems

Indigenous Knowledge is cultural knowledge accumulated and transferred from one generation to the next. This provides an alternative means to developing practical solutions for learning problems that are contextually and culturally relevant and applicable for local communities of people (Gumbo, 2015). Participant 2 commented:

"I believe that Indigenous Knowledge has to do with how things were done. In the olden days, people started seeing that there were certain problems and they needed to identify what... [to] do".

While Participant 5 accentuated that learning through problem-solving occurs through collaborative group efforts:

"We engage in problem-solving by using cooperative learning skills".

And through social interaction, draws knowledge and skills from the ancestral memories and wisdom of their people:

"We engaged the elderly people to share with us ... [their] methods and knowledge".

Which resonates well with Gumbo's (2015, p.70) recommendation that: *"indigenous teachers should mentor their peers, and they need to interact with the community to gain wisdom from the elders"*.



Figure 4.5: Photographic evidence of participants working collaboratively together to solve a case scenario problem by developing an indigenous technological bridge artefact. Photographs published with written consent of the participants.

Figure 4.5 shows participants working together to create an indigenous technical bridge artefact to solve a case scenario problem. Figure 4.6, displayed on the next page, provides photographic evidence of the Mind Map that participants collaboratively created showing their pedagogical use of Indigenous Knowledge in order to explain *Food Preservation* as a core content area of the Senior Phase Technology Curriculum.



Figure 4.6: Photographic evidence of the Mind Map that participants collaboratively created showing their pedagogical use of Indigenous Knowledge to explain *Food Preservation* as a core content area of the Senior Phase Technology Curriculum. Published with the written consent of the participants.

Participants furthermore, took social and environmental factors into consideration while enthusiastically solving a problem for the community, in the case scenario that I presented to them. In the words of Participant 5:

"Our group members were full of energy on compiling the information and building the bridge ... solving [the] people's problem by building a strong and steady bridge".

This indicates that the learning activities of the short-learning programme is in direct alignment with the objectives that the Department of Basic Education (2011, p. 8) envisions for the subject Technology Education, i.e.: *"the use of knowledge, skills, values and resources to*

meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration".

Participants 1 and 2 indicated that the bridge should be “safe”, “non-slippery”, “stable”, “wide enough”, and “easily accessible” for the community in the given scenario. Participants 1, 2 and 1 added that the proposed bridge should be “environment friendly”, while Participant 4 stressed that: “the bridge should not harm the environment”. These social and environmental considerations are consistent with the content of African indigenous education that should be drawn from the physical, natural and social environments, which are intrinsically interwoven with the religious and spiritual life of the people (Kisanji, 1999). Furthermore, indigenous education upholds that Nature (the Earth) should be respected, for the Earth shall swallow up anyone who fails to respect Nature (Obanya, 2018).

4.4.3 Participants' application of the steps of PBL in the design process and construction of a bridge artefact, while acquiring Indigenous Knowledge and skills

Table 4.3 reports on the qualitative findings derived from my qualitative thematic data analysis pertaining to the acquisition of PBL. Participant responses, reflected by verbatim quotations, provides evidence for the attainment of all steps of PBL applied throughout the design process and construction of the bridge artefact.

Table 4.3: Qualitative findings related to participants' application of the steps of PBL in the design process and construction of a bridge artefact during the SLP, while acquiring Indigenous Knowledge and skills

PBL Steps	Evidence that Teachers applied PBL Steps in the Design Process during the SLP on Indigenous Knowledge	Evidence for the Acquisition of Indigenous Knowledge and Skills
Conceptualise	“Technology... has an interrelationship between community, environment” (Teacher 1 (T1))? “The infusion of humanity and culture in teaching and learning of technology it's so mind-blowing” (T3).	“Increased interest of drawing upon the Indigenous Knowledge ... by the help of our lecturer it makes it easier ... to get with the course” (T5). “Conceptualisation simulates creativity and critical thinking skills” (T3).
Discuss the problem context	“Village people ... want to cross the river ... people need a bridge” (T1).	“Determine resources to solve the problem” (T3). “We engage in problem-solving by using cooperative learning skills” (T5).
Identify knowledge and needs	“... the bridge must be strong, stable, wide enough, safe, kind of mechanism to easily get access to stairs, ramp ... must be environmental friendly, non-slippery wooden surface” (T1). “... safety, environmentally friendly, the cost, durability” (T2). “The materials ... to build the bridge should not	“Solution must be based on knowledge and how to apply it” (T2). “IK and sophisticated knowledge were used to meet our needs ... we engaged the elderly people to share with us ... methods and knowledge” (T5).

PBL Steps	Evidence that Teachers applied PBL Steps in the Design Process during the SLP on Indigenous Knowledge	Evidence for the Acquisition of Indigenous Knowledge and Skills
	harm the environment and it should be cost effective" (T4).	
Formulate learning objectives	"Formulate learning objectives that are directly linked to the problem" (T3). "... interact constructively and promote group work" (T2). "The design should be constantly tested for the purpose intended" (T2). "If the ideas not meet the requirements we must adapt it until they do" (T1).	"The SLP ... helped us to 133tilized133 how we can formulate our learning objectives" (T5).
Investigate	"Acquire appropriate resources ... making informed decisions" (T3). "We also use knowledge of the elderly people to investigate" (T5).	"Investigate what materials and machinery will be needed to build the bridge" (T5). "If the bridge ideas does not serve the purpose it should be re-evaluated" (T4).
Design and develop	"... draw a few ideas to solve the problem and choose the best one... changes were made and one needs to go back to the drawing board" (T1). "Our task was to design a bridge [prototype] make up out of recycle material" (T1). "Evaluate each [idea] in terms of advantages and disadvantages" (T3).	"... saver working practices, skills are increasing, better 133tilized133z... suitability and purpose of the material, the impact ... towards the environment" (T1). "All group members know from start what their role will be ... complete their part to the best of their ability" (T1). "... will be able to critically reflect" (T3). "learning activities ... linking prior knowledge to new knowledge [IK]" (T5).
Assess	"... group member also see the value that he/she has contributed in solving the problem successfully" (T1). "Our group members were full of energy on compiling the information and building the bridge ... solving people's problem by building a strong and steady bridge" (T5).	"... every member of the group shared accountability and responsibility" (T2). "Give group members specific tasks. This will ease the task on each member ... and the group will meet their deadlines. Communication in this regard is vital" (T4). "... and cooperative skills were attained" (T5).

4.4.4 Development of SDL abilities amongst Technology teacher participants

The findings indicate various exemplars where Technology teachers applied PBL steps as part of an SLP to obtain Indigenous Knowledge and skills (Table 4.2). Teachers conceptualized the construct of Indigenous Knowledge and T3 mentioned "The infusion of humanity and culture in teaching and learning of technology it's so mind-blowing". Participants discussed the problem contexts and outlined the knowledge and needs required to solve these. Building a bridge should include a mechanism for easy access, e.g. by using stairs or a ramp, it should be environmentally friendly, using a non-slip wooden surface (T1) and it should be cost effective (T4). Participants were required to engage constructively and collaborate in the design and development of the bridge as part of the learning objectives. The participants also stated that the bridge artefact should also be tested for strength. Participants used various resources and also emphasized knowledge of the elderly in the village (T5). Participants

designed and developed a bridge prototype using environmental friendly and recycled materials. During assessment, team members determined individual as well as group contribution to solve the problem. T5 noted that:

“Our group members were full of energy on compiling the information and building the bridge ... we achieved in solving people’s problem by building a strong and steady bridge”.

Participants developed numerous skills during the SLP. For example, the ability to develop an interest in Indigenous Knowledge (T5), enhance critical thinking (T3), identify knowledge and emphasize experiences of the elderly (T5), formulate learning objectives (T5) and investigate various resources (T5). Technology teachers obtained particular skills during design and development of the artefact, such as group management and identification of members’ roles (T1), critical reflection (T3) and elaboration on their learning (T5). Moreover, participants shared accountability and responsibility (T2), met deadlines, communicated effectively (T4) and effectively cooperated (T5). As a result, attending the SLP provided for teachers with more nuanced understandings of Indigenous Knowledge systems, and an array of skills to solve an indigenous real-world problem. In addition, Table 4.4 shows numerous examples of core SDL abilities that Technology teachers developed during the SLP.

Table 4.4: Qualitative findings from the focus-group interview related to the development of SDL abilities amongst Technology teacher participants

Self-directed learning is the process in which: “ <i>individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes</i> ” (Knowles, 1975:18).	
Core SDL Abilities	Evidence for the development (or at least awareness) of SDL abilities amongst Technology teachers
Taking initiative, with or without the help of others	“...it is very important that we stay in contact with upskilling ourselves” (T1). “...but at the end of the day it is upon you as an individual, you require this in order to upskill yourself...as the teacher it is a calling. We do it for the love of teaching and we take it to the learners... where they can use [it] as self-employment” (T1). “Constantly upskill yourself with the latest trends... When you are able to keep up with such trends, the quest to... do more or to know more... How do you then sharpen your skills?... because it is not necessary to go through formal course, hence you could just do short courses (T3).
Diagnosing learning needs	“... technology is not only about the doing and drawing part ... I am not that good with the drawing part of technology, because we need to draw the bridge first on paper and build them, so I am lacking with the drawing part” (T1). “...at the end of the day it is upon you as an individual [T1]
Formulating learning goals	“... if you set yourself goals you need to have step by step process you will follow, if you see that you have missed something ... you can go back to the drawing board and try to see how can you plan around whatever that is hindering you from attaining your goals” (T2).

Self-directed learning is the process in which: “ <i>individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes</i> ” (Knowles, 1975:18).	
Core SDL Abilities	Evidence for the development (or at least awareness) of SDL abilities amongst Technology teachers
	“... I want to attain certain goals and how I am going to do it” (T3).
Identifying human and material resources for learning	“... find resources to finish this project of the bridge, so it made me more wiser ... and also how you planning to get assistance or knowledge that you require, you need assistance from the HOD's and the school, I do believe that there are many ways of getting necessary help that you require when you use that tool” (T2). “Mam... said earlier that she has difficulty in the drawing part of the technology. There are few things that she can do... to... finally get the drawing part right, because I also had the same problem. What I did was... I engaged with someone who knows how to draw... we made arrangements, and he did few drawings for me. There are a lot of things that you can do” (T2). “... find association or organisations that deals with technology to liaise with them. Attend conferences so that we get to learn. If there are any technological roadshows... attend, you can also [do] research” (T3).
Choosing and implementing appropriate learning strategies	“... find association or organisations that deals with technology to liaise with them. Attend conferences so that we get to learn. If there are any technological roadshows you will then attend, you can also research. Constantly upskill yourself, on the radio they talked about this device ... the parts of cars do have sensors so this device will be able to sense the problem and automatically communicate with you. When you are able to keep up with such trends, the quest to get to do more or to know more, how do you then sharpen your skills”(T3). “It is important because indigenous is what learnt at home, and we come to apply it in school we go deeper... <i>Ons delf net dieper in dit, nie net oppervlakkig nie</i> [Translated from Afrikaans as: <i>We only delve deeper in it, not only superficially</i>].” (T1)
Evaluating learning outcomes	“... it gave me an insight as to what is expected from the learners as we have been doing it now as educators ... when I go back to my learners I can explain what is expected from them, where they need to go to find resources to finish this project of the bridge, so it made me more wiser” (T2).

As the description of self-directed learning, which I included at the top of Table 4.3, is most widely accepted by researchers within the field to include the core abilities of SDL, data obtained from the focus-group interview was thematically analyzed according to these SDL abilities, as identified by Knowles (1975). The findings that emerged from my qualitative data analysis from the focus-group interview clearly provide evidence (Table 4.4) that the SLP provided teachers with more nuanced understandings of SDL, and guided them in developing skills necessary for SDL.

My qualitative results show that the senior phase Technology teachers in my case study successfully applied their culturally accumulated indigenous expertise to their own professional development in the core subject areas of the senior phase Technology Curriculum, resulting in culturally sensitive senior phase Technology teachers. Given their optimistic attitudes and great excitement with which they accepted Indigenous Knowledge to inherently become part of their career, my participants' potential incorporation and use of Indigenous Knowledge and indigenous technologies in their Technology Education classrooms

appears eminent.

This research indicated that an SLP provided valuable opportunities for Technology teachers to further develop their knowledge and skills concerning Indigenous Knowledge and enabled them to implement IK by developing a bridge of recycled materials. PBL was applied as pedagogical strategy, participants were inspired and acquired numerous skills involved in indigenous knowledge.

4.4.5 Findings from the qualitative open-ended questionnaire completed by participants at the end of the 3rd intervention cycle

At the end of the 3rd intervention cycle, a qualitative open-ended questionnaire was administered to the five participants in order to generate data on the school subjects they teach, their school infrastructure and the availability of resources, the geographical information of the schools where they teach, their teaching experience and their professional qualifications to teach higher-level technology. Furthermore, their pedagogical practices in Technology Education, problem-based learning, cooperative learning, their views on the infusion of Indigenous Knowledge into Technology Education, their SLP experience in the infusion of Indigenous Knowledge into Technology Education, including their professional development goals, which are based on the specific knowledge and skills they lack, as identified during the SLP was explored.

Table 4.5 (on the following page), reports on participant's pedagogical practices, views on problem-based learning and cooperative learning, experiences and views on the infusion of Indigenous Knowledge into Technology Education during the 3rd intervention Cycle, as well as their professional developmental goals

Table 4.5: Participant's pedagogical practices, views on problem-based learning and cooperative learning, experiences and views on the infusion of Indigenous Knowledge into Technology Education during the 3rd intervention Cycle, as well as their professional developmental goals

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
PARTICIPANTS' PEDAGOGICAL PRACTICES IN TECHNOLOGY EDUCATION					
How do you plan a Technology lesson?	Ensuring the learners Understand the concept of technology, the steps in The design process	With using the old methods of a lesson plan with the introduction, body, and conclusion activity. I also Make use of the CAPS Document and ATP.	I follow the CAPS doc, textbook, POA, ATP & draw a lesson plan from the above documents.	By following my lesson plan CAPS policy hands on technological methods text books help a lot.	Used the conventional lessons plans to plan for tech lessons.
How will you contextualize (show the relevance) the teaching Of Technology themes (e.g. the Technology design process/ structure/ mechanical systems and control/ electrical/ processing etc.) to learners?	Refer to the structures that are already in the community example, power pylons, cellphone towers, power line etc.	Bring the outside world to the class	Bring the outside to class, frame structures the birdhouse now it was build & show it to them	Bring starting from known to unknown information	I am not familiar with this concepts as I am new in the subject.
PROBLEM-BASED LEARNING					
What are your views on using problem-based learning in the Technology classroom? Give an example of a lesson in which you use Problem-based approaches.	Problem-based learning enhance critical thinking. In a lesson, I give learners a Scenario as by they have to identify the problem.	It is good because learners can learn the skill to solve problems	It is good practices because it brings the outside into the classroom. The Building of a bridge to cross the river.	By linking a real life problems of my township so that they can be familiar with it	As a teacher who is not a specialist on this subject was never exposed to these approaches

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
Did this SLP change your views on the use of problem – based learning (PBL) methods in the Technology classroom? Motivate your answer.	Absolutely, I will definitely use PBL more in the future. Learners must identify problems in the community e.g. health safety and come up with solutions.	Absolutely, I will definitely use PBL more in the future. Once a learner is challenged to solve a problem on their own... they will always remember the content.	Absolutely, I will definitely use PBL more in the future. Technology is all about problem– solving and if one follow the steps you cannot go wrong.	Yes, it did. It makes me to solve problems by taking short cut to deal with real life problems.	Absolutely, I will definitely use PBL more in the future.
Please provide an example of how you would use problem – based learning (PBL) to teach a topic in the Technology CAPS classroom.	Problem: Refuse removals in our town. Learners must come up with suggestions on how to deal with the problem as well as coming up with both short and long term solutions, e.g. placement of bigger bins at strategic places.	Once a learner is challenged to solve a problem on their own they can solve the problems themselves.	How to design and make a watchtower for the farmer to watch over his field. Identify the problem, design some possible ideas, choose the best possible one and make it.	With equipped with resources mine engagement with CAPS policy will be reflected and have a proof as a results of what I was teaching my lesson plan.	By presenting learner with a scenario or case study.
COOPERATIVE LEARNING					
What are your views on using cooperative learning in the Technology classroom? Give an example of a lesson in which you use cooperative learning approaches.	Cooperate learning promotes group work.	It is a good thing because then your learners can see that all subjects are interrelated	It is good practices, because the learners will see that all the subjects are linked together, when complete the PAT.	AND-gate and OR-gate knowledge and working together as a team	I am fully in favor of cooperative learning however, I never employed this approach during teaching and learning.
Did this SLP change your views on the use of cooperative learning (CL) methods in the	Yes, it did. Cooperative learning promotes group work as well as sharing the little resources we have.	Yes, it did. I now know that it is very important for the learners to get a view from one another.	Yes, it did. It make it clear that all task are linked to each other.	Absolutely, I will definitely use PBL more in the future. I realized that I used to channel my learners when	Absolutely, I will definitely use PBL more in the future. However, learner population

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
Technology classroom? Motivate your answer.				Solving problems of their own. I will give direction on how to solve.	In a class could be an impediment/barrier.
Please provide an example of how you would use cooperative learning (CL) strategies to teach a CAPS topic in your classroom.	Group learners together and introduce to them a scenario whereby they have to identify the problem.	Place learners into groups and give them the opportunity to solve the problem in their groups.	To measure correctly, we need math background to do it correctly.	Grouping my learners in groups and giving them the opportunity to explore new knowledge to solve/ tackle the problem.	I would strongly use this strategy during conceptualization process, design process and the actual building of the model.
INFUSION OF INDIGENOUS KNOWLEDGE INTO TECHNOLOGY EDUCATION					
What are your views on including Indigenous Knowledge in the teaching of Technology?	As the Curriculum across the board requires that learners of different cultures... [use] ...Indigenous Knowledge as one of the concepts to introduce culture.	I believe that it is a good thing as the learners can gain new knowledge about how things were done many years ago.	It is interesting and it will open up...communication gaps so that we will learn from different cultures	Exciting and jubilating, because it closes the gap from what we know to what we will learn in future	It is a brilliant idea as learners would be moving from the known to unknown
How can a teacher include Indigenous Knowledge into a Technology (CAPS) lesson?	By referring to the past... by asking learners to go back home and ask their elderly people on how things were done in the past. It also encourages parental involvement.	By making real life examples. E.g. The teacher can explain to the learners that year ago there were no bridges and ask the learner what the indigenous way... [is] ...of crossing rivers.	By using clay to build models By using the skin of animals to make structures stable.	By following CAPS policy will make it possible for me to include (IK) in my lesson by asking my learners background	By researching IK and also enquiring... [Knowledge] ...from elders, and making references at the library and inculcating the culture of research among learners.
What are the challenges that Technology teachers face in infusing Indigenous Knowledge in	The fact that learners are from different backgrounds and will tell separate	Because we are sitting with a new learner they don't have so much knowledge about indigenous practices.	Some learners may not have relatives to ask how they	Diversity of cultures make it difficult to infuse indigenous knowledge	Lack of resources Lack of in-service training

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
senior phase technology?	Stories might be learnful but very time consuming.		Survived in past years.		
Which conditions are ideal for the infusion of Indigenous Knowledge in senior phase technology in the South African context?	By involving parental involvement and also referring back to the past will enlighten the interest of learners.	When you are teaching the learners about structures.	The background information different cultures.	Backgrounds of learners and diversity of their cultures	Well-resourced schools with appropriate classrooms.
Which threats/ hindrances within in the current South African school system could inhibit successful infusion of Indigenous Knowledge in senior phase Technology Curriculum?	Unsafe classrooms, the lack of a safe technology class. Huge number of learners in just one class.	Racial issues and learners that come from different cultures and backgrounds.	Lack of training... Lack of resources... [for] ...example Internet connections for teachers and learners to do research.	Lack of training make it difficult. Lack of resources. Lack of money	The design of our school and classrooms Issues of safety Resources
RATED EXPERIENCES OF THE SLP ON THE INFUSION OF INDIGENOUS KNOWLEDGE INTO TECHNOLOGY EDUCATION					
	Good – it definitely made an impact and helped me in my professional development		Good – it definitely made an impact and helped me in my professional development		
		It was fantastic and I learned a lot, I cannot wait to implement what I have learned in practice		It was fantastic and I learned a lot, I cannot wait to implement what I have learned in practice	It was fantastic and I learned a lot, I cannot wait to implement what I have learned in practice

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
How would you describe contextualized Technology teaching?	The teacher should first start by making use of own knowledge skills. The Teacher should have baseline assessment.	It is teaching in such a way that you can bring past experience of learners and what they know and learned In the past in the present time/ classroom.	It is when pre – post knowledge of the learners must be identified then the teacher can move With the learners from the known to The unknown & experiences.	I realized that the new information was as guideline for sophisticated learners while olden technology they used what they have to solve their problems.	It is very interactive, innovative and stimulates the thinking process using a sustainable resource and applying indigenous knowledge in developing Process.
What are the difficulties that you anticipate in implementing and teaching methods/ strategies introduced during this SLP?	The difference in socio-economic standard... ..well as parental involvement in my community. Lack of basic resources e.g. Lab, cellphone, data and Wifi.	The time... ..is very limited and sometimes it just felt as if we were rushing some things.	I was made know that's best to start with the case study First, then move over to the resources task & then the making Model in that the Learners will be more at hand	Number of us were coming from Promosa, so it was difficult for me to adjust. The social part of it... ..they reason in Afrikaans and later they translate into English... ..which is fair.	[Lack of]...teaching and learning resources. [Lack of] ...classroom that are specifically for teaching technology. Issues of safety during teaching and Learning.
Did this SLP change your views on the role of reflection in one's professional development? Motivate Your answer.	Yes, one can never know it all and our diversity in culture make more room for this.	Yes, you as the educator always have space for improvement.	Yes, sometimes we as teachers we have To keep up with the Latest trends and changes.	Yes, it does because new method of teaching and learning were introduced to me.	Yes indeed, it will assist a lot, as one will be able to look back, and come up with Ideas on how to improve in The future.
Explain how you made use of shoestring approaches in your Classroom (e.g. teaching Technology topics with Every day, cheap Materials) in the past.	Learners are asked to use materials that can be recycled and... [which do] ...not harm people or the environment	There... [are] ...so much things that you can do to ensure your learners are not bored in class, you should just do a little research and find ways to help them.	[The] Shoestring approach... ..is still helpful, especially when resource material is a Problem.	Yes, it does now I can realize that recyclable materials are used to minimize littering in our schools.	I have never used this approach before as I am new in this learning area.

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
General comments	The SLP was very exciting and informative. More should be scheduled for the future. THANKS	Over and above all I found the SLP very fruitful and I definitely learned a lot.	It was very enriching time & will definitely Apply the approaches in class.	The short course program helps with new knowledge to explore the new Approach to teaching and learning.	This workshop was mind blowing and thought provoking. I personally feel that we need to interact More often so that we can keep learning from each other.

4.4.5.1 Participants' pedagogical practices in Technology Education

Two questionnaire items requested information from the participants with regard to their androgogic practices. The one item concerned lesson planning, while the other item related to participants pedagogical skills of the learning themes in Technology Education.

4.4.5.2 Lesson planning

The questionnaire requested from participants to explain, in their own words, how they plan their lessons for Technology Education. From the participants' responses, it becomes clear that all five participants are using conventional ways of planning their lessons, which is directed towards reaching the specific learning outcomes prescribed by the senior phase CAPS document. For example, Participant 2 wrote:

“...using the old methods of a lesson plan with the introduction, body, and conclusion activity. I also make use of the CAPS document and ATP”.

While according to Participant 3:

“I follow the CAPS doc, textbook, POA, ATP & draw a lesson plan from the above documents”.

4.4.5.3 Pedagogical contextualization on of themes in Technology Education

When participants were asked to explain the pedagogical manner in which they contextualization the various learning themes in Technology Education, three participants indicated that they make use of real-life socially constructed examples from the immediate communities of their learners. Participant 1 explained that she:

“Refer to the structures that are already in the community... [, for] ...example, power pylons, cellphone towers, power line, etc.”

And the response of Participant 2 was that he:

“Bring[s] the outside world to the class”.

Participant 5, on the other hand, noted that:

“I am not familiar with the[se] concepts, as I am new in the subject”.

4.4.5.4 Problem-based learning

The questionnaire furthermore, collected data with regard to participants' viewpoints on problem-based learning. The first four participants responded positively towards the use of problem-based learning in Technology Education, while Participant 5 indicated that he had never been exposed to the problem-based learning approach. Participant 1 linked this approach with the development of critical thinking skills:

"Problem-based learning enhance critical thinking. In a lesson, I give learners a scenario... they have to identify the problem".

Participant 2 also answered favourably by saying:

"It is good, because learners can learn the skill to solve problems".

While Participants 3 and 4 praised problem-based learning for the opportunity to find solutions to real-life problems that the learners are familiar with in the Townships. In the words of Participant 3:

"It is good practices because it brings the outside into the classroom, e.g. the building of a bridge to cross the river".

Which is further supported by the response of Participant 4:

"By linking real life problems of my township, so that they can be familiar with it".

All five participants indicated that the SLP changed their views on the use of problem-based learning methods in their Technology classrooms, while four participants said that they intend to make more use of problem-based learning in the future. According to Participant 2:

"Once a learner is challenged to solve a problem on their own... they will always remember the content".

While Participant 3 wrote:

"Technology is all about problem-solving... if one follow the steps you cannot go wrong".

Participants 1 and 4 again linked problem-based learning with solving real-life problems in their communities. For example, Participant 1 said:

"Learners must identify problems in the community e.g. health safety and come up with solutions".

When participants were asked to provide examples of how they would make use of problem-based learning to teach a topic from the Technology CAPS in their classrooms, Participant 1 replied:

“Problem: Refuse removals in our town. Learners must come up with suggestions on how to deal with the problem as well as coming up with both short and long term solutions, e.g. placement of bigger bins at strategic places”.

While Participant 3 wrote:

“How to design and make a watchtower for the farmer to watch over his field. Identify the problem, design some possible ideas, choose the best possible one and make it”.

4.4.5.5 Cooperative learning

The questionnaire also asked the participants what their points of view were regarding the use of cooperative learning in Technology Education, and also provided an example of the lessons to be learned from this approach. . Participant 1 answered:

“Cooperative learning promotes group work”.

While Participant 4 replied with:

“AND-gate and OR-gate knowledge and working together as a team”.

It is not clear why Participants 2 and 3 indicated that cooperative learning would allow their learners to see that all subjects are interrelated. It can only be speculated that these two participants might have misunderstood this particular questionnaire item.

When asked whether or not the SLP changed participants’ viewpoints on the use of cooperative learning methods in their Technology classrooms, Participant 1 responded with:

“Yes, it did. Cooperative learning promotes group work as well as sharing the little resources we have”.

While Participant 2 wrote:

“Yes, it did. I now know that it is very important for the learners to get a view from one another”.

Participant 4 indicated that the exposure to cooperative learning during the SLP made her reconsider the manner in which she has been facilitating problem solving exercises with her learners:

“Absolutely, I will definitely use PBL more in the future. I realized that I used to channel my learners when solving problems of their own. I will give direction on how to solve”.

When the participants were also asked to provide an example of how they would use cooperative learning (CL) strategies to teach a CAPS topic in their Technology classroom, Participants 1, 2 and 3 gave similar answers, which is summarized in the following response received from Participant 3:

“Grouping my learners in groups and giving them the opportunity to explore new knowledge to solve/ tackle the problem”.

While Participant 5 said:

“I would strongly use this strategy during [the] conceptualization process, design process and the actual building of the model”.

It is not clear why Participant 3 wrote:

“To measure correctly, we need math background to do it correctly”.

However, one could merely surmise that he is possibly referring here to the measurements that the participants were required to perform during the SLP in order to construct the bridge artefact.

4.4.5.6 Infusing Indigenous Knowledge into Technology Education

One questionnaire item asked the Participants to share their views on the inclusion of Indigenous Knowledge in their teaching of Technology Education. Participants 1 and 3 emphasized the value of Indigenous Knowledge in cultivating mutual understanding and communication between different cultures, and to enable learners the opportunity to learn from each other’s cultures, exemplified by the following two responses received from Participants 1 and 3 respectively:

“As the Curriculum across the board requires that learners of different cultures... [use] ...Indigenous Knowledge as one of the concepts to introduce culture”.

“It is interesting and it will open up that communication gaps so that we will learn from different cultures”.

While Participants 4 and 5 have expressed their enthusiasm for instilling Indigenous Knowledge in their technology teaching, as follows:

“Exciting and jubilating, because it closes the gap from what we know to what we will learn in... [the] ...future”.

And

“It is a brilliant idea as learners would be moving from the known to unknown”.

For Participant 2, on the other hand, the value of infusing Indigenous Knowledge into Technology Education, is that learners gain knowledge about the manner in which past generations used to solve problems:

“I believe that it is a good thing as the learners can gain new knowledge about how things were done many years ago”.

When participants were asked to explain how they would include Indigenous Knowledge in a Technology (CAPS) lesson, Participants 1 and 5 indicated that they would encourage learners to learn more about the accumulated indigenous knowledge, traditions and practices of their respective cultures, by drawing on the ancestral memories and wisdom of their elders. In the words of Participant 1:

“By referring to the past... by asking learners to go back home and ask their elderly people on how things were done in the past. It also encourages parental involvement”.

While Participant 5 responded with:

“By researching IK and also enquiring... [knowledge] ...from elders, and making references at the library and inculcating the culture of research among learners”.

In addition, the questionnaire asked participants to identify the potential challenges they might face with regard to the infusion of Indigenous Knowledge into higher-level Technology Education. According to Participants 1 and 4, the harvesting of indigenous knowledge, represented in the classroom by the rich diversity of learners’ different cultures, could be meaningful to learning, but it could also be very time consuming.

“The fact that learners are from different backgrounds and will tell separate stories might be meaningful, but very time consuming”.

“Diversity of cultures make it difficult to infuse indigenous knowledge”.

Participants 2 and 3 expressed their concern that there might be learners in their classes who might not have access to the accumulated Indigenous Knowledge of their people. Explained by Participant 3 as follows:

“Some learners may not have relatives to ask how they survived in past years”.

And for Participant 5, a lack of available resources and opportunities for in-service teacher training, constitute the main challenges that he expects to encounter during the infusion of Indigenous Knowledge into Technology Education:

“Lack of resources. Lack of in-service training”.

His response emphasizes the current lack of professional development opportunities for In-Service Technology teachers to empower themselves with the knowledge and skills needed to effectively infuse Indigenous Knowledge into Technology Education – a gap that my study intended to address through the development and delivery of a short-term learning program designed to provide Technology teachers such an opportunity.

Participants were furthermore asked which conditions are ideal for the infusion of Indigenous Knowledge in Senior Phase Technology in the South African context. Participants 1 wrote:

“By involving parental involvement and also referring back to the past will enlighten the interest of learners”.

While Participants 3 and 4 indicated the background information of learners from diverse cultures:

“The background information different cultures”.

“Backgrounds of learners and diversity of their cultures”.

For Participant 5, the ideal conditions for the infusion of Indigenous Knowledge into Technology Education are:

“Well-resourced schools with appropriate classrooms”.

, When participants were asked which threats or roadblocks exist in the South African educational system that could prevent the effective integration of indigenous information into senior phase technology curricula Participant 1 responded with:

“Unsafe classrooms, the lack of a safe technology class. Huge number of learners in just one class”.

While Participants 3 and 4, respectively, pointed towards insufficient opportunities for teacher professional development and training, as well as the lack of available resources.

“Lack of training... Lack of resources... [for] ...example Internet connections for teachers and learners to do research”.

“Lack of training make[s] it difficult. Lack of resources. Lack of money”.

For Participants 1 and 5, the physical infrastructure of schools, safety issues at schools, and lack of available resources, are some of the main barriers to be concerned about:

“Unsafe classrooms, the lack of a safe technology class. Huge number of learners in just one class”.

“The design of our school and classrooms. Issues of safety. Resources”.

Only Participant 2 indicated that racial issues, existing between learners from diverse cultural backgrounds, may be a menace for the effective infusion of Indigenous Knowledge into Technology Education:

“Racial issues and learners that come from different cultures and backgrounds”.

When participants were asked to rate their experiences of the SLP on the infusion of Indigenous Knowledge into Technology Education, Participants 1 and 3 rated their experience as:

“Good – it definitely made an impact and helped me in my professional development”

While Participants 2, 4 and 5 rated their experience of the SLP as:

“It was fantastic and I learned a lot, I cannot wait to implement what I have learned in practice”

When participants were asked how they would describe contextualized Technology teaching, Participants 2 and 3 associated it with using past learning experiences of learners to resolve new problems. Participant 2 responded with:

“It is teaching in such a way that you can bring past experience of learners, and what they know and learned in the past, in the present-time classroom”.

While Participant's 3 wrote:

“It is when pre – knowledge of the learners must be identified then the teacher can move with the learners from the known to the unknown... ..experiences”.

Participant 5, on the other hand, linked the application of Indigenous Knowledge with contextualized Technology teaching:

“It is very interactive, innovative and stimulates the thinking process using a sustainable resource and applying Indigenous Knowledge in developing process”.

The qualitative questionnaire furthermore asked participants to identify possible difficulties that they anticipate for the implementation of the teaching methods/strategies introduced to them during the short learning programme. Participants 1 and 5 pointed towards a lack in available resources, lack of specialized classrooms/laboratories/facilities for Technology Education, poor parental involvement, safety issues, and lack of Internet connectivity.

In the words of Participant 1:

“The difference in socio-economic standard... ..well as parental involvement in my community. Lack of basic resources e.g. Lab, cellphone, data and Wi-fi”.

And Participant 5:

“[Lack of] ...teaching and learning resources. [Lack of] ...classrooms that are specifically for teaching technology. Issues of safety during teaching and learning”.

While Participant 4 indicated that the social aspect of language is a barrier, in particular where the language of instruction differs from that of the home language of teachers and learners.

“[A] ...number of us were coming from Promosa, so it was difficult for me to adjust. The social part of it... ..they reason in Afrikaans and later they translate into English... ..which is fair”.

And Participant 2 was concerned about the time that these new teaching methods/strategies require:

“The time... ..is very limited and sometimes it just felt as if we were rushing some things”.

When participants were asked whether or not the short learning programme changed their views concerning the role that reflection plays in their professional development, all five participants indicated that the SLP did change their views in this regard. Participant 2 remarked:

“Yes, you as the educator always have space for improvement”.

While Participant 3 emphasized the need for Technology teachers to keep up with the latest trends in Technology Education:

“Yes, sometimes we as teachers we have to keep up with the latest trends and changes”.

And, according to Participant 4, Technology teachers can continue to hone their skills through the use of modern teaching and learning approaches in Technology Education.:

“Yes, it does because new method of teaching and learning were introduced to me”.

The questionnaire also asked participants to explain how and why they made use of shoestring approaches in their classrooms (e.g. teaching Technology topics with every day, cheap materials) in the past. Participants 1 and 4, took environmental issues in consideration when they answered:

“Learners are asked to use materials that can be recycled and... [which do] ...not harm people or the environment”.

And

“Yes, it does now I can realize that recyclable materials are used to minimize littering in our schools”.

While Participant 2 mentioned that shoestring methods are useful in his classroom to combat learner boredom:

“There... [are] ...so much things that you can do to ensure your learners are not bored in class, you should just do a little research and find ways to help them”.

And Participant 3 make use of shoestring approaches when resource materials are not available:

“[The] shoestring approach... ...is still helpful, especially when resource material is a problem”.

Table 4.6: Professional developmental goals indicated by participants in the 3rd intervention cycle, based upon their knowledge and skills gaps that they identified during the SLP

	PARTICIPANT 1	PARTICIPANT 2	PARTICIPANT 3	PARTICIPANT 4	PARTICIPANT 5
PARTICIPANTS' PROFESSIONAL DEVELOPMENTAL GOALS (BASED UPON THEIR KNOWLEDGE AND SKILLS GAPS) IDENTIFIED DURING THE SLP					
Gender	♀	♂	♂	♀	♂
Knowledge on CAPS themes				System and control Logic Gates	
Laboratory/Workshop skills (e.g. the Technology design process)	Need a proper workshop and not my everyday classroom	I really need to make a way to get resources for my learners to work in class.	At our school we do not have a workshop/ lab for tech. so I would like it to be trained on behaving / working in a lab safety, etc.	Electricity and electrical procedures Presentation of how to connect components on matter board	In-appropriate classroom for technology
Problem-based learning approaches		I need to create all get have problem which my learners can solve themselves	Just to keep up with latest trend	How to link low order questions to high order questions	
Cooperative learning techniques			Sometimes time management can be a struggle, how to manage it well	Shortage of resources material makes it difficult for me to explore.	
Shoestring approaches (using inexpensive materials in PBL approaches)			It will be best maybe for a longer time for this short course so that one is fully equip.		Need assistance to facilitate this approach
Reflection			Time well spent		

Table 4.6 reports the professional developmental goals identified by participants in the 3rd intervention cycle, which they derived from their reflections on possible gaps in their knowledge and skills during the SLP. These developmental goals are specific to each of the participants, as can be seen from the variety of goals.

When asked to comment on the short learning programme, all five participants commented very positively, and requested that similar short learning programmes should be presented in the future for their continuous professional development as Senior Phase Technology teachers.

Participant 1 commented:

The SLP was very exciting and informative. More should be scheduled for the future. THANKS

Participant 2 wrote:

Over and above all I found the SLP very fruitful and I definitely learned a lot.

For Participant 3:

It was very enriching time & will definitely apply the approaches in class.

And Participant 4 noted that:

The short course program helps with new knowledge to explore the new approach to teaching and learning.

While Participant 5 enthusiastically remarked:

This workshop was mind blowing and thought provoking. I personally feel that we need to interact more often so that we can keep learning from each other.

I furthermore applied the professional development criteria presented in Chapter 2 (Table 2.1), to rate the pre- and post-intervention levels of professional development of participants in the third intervention cycle of my study. Table 4.7 below, shows a heuristic matrix, mapping Technology teachers' pre- and post-intervention professional development, with regard to classroom interaction, practical work, technology and society, and assessment skills, as originally suggested by Rogan and Grayson (2003). Tables 2.1 and 4.7 also include criterial for the rating of self-directed learning skills, as proposed by Sebotsa et al (2019). Expanding upon these dimensions, I developed criteria for the rating of problem-based learning skills in Table 2.1, and included the rating of problem-based learning skills into the heuristic matrix analysis reported in Table 4.7. The general impression derived from Table 4.7 indicates that Technology teachers benefited from the SLP. The interpretation of the table above are supported by participants' views as expounded on in Section 4.4 above.

Table 4.7: Heuristic matrix mapping Technology teachers' pre- and post-intervention levels of professional development with regard to classroom interaction, practical work, technology and society, assessment skills, self-directed learning and problem-based learning skills (adapted from Rogan and Grayson (2003), with the self-directed learning skills proposed by Sebotsa et al (2019), with the additional inclusion of problem-based learning skills.

PRE- (X) AND POST (0) INTERVENTION PROFILING HEURISTIC		Classroom Interaction					Practical Work (Application of the design process)					Technology & Society					Assessment					Self-Directed Learning					Problem-Based Learning				
		0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Teacher 1	Pre-Intervention		0					0					0					0					0					0			
	Post-Intervention			x						x			x					x				x						x			
Teacher 2	Pre-Intervention		0					0					0					0					0					0			
	Post-Intervention			x						x			x					x				x						x			
Teacher 3	Pre-Intervention		0					0					0					0					0					0			
	Post-Intervention			x					x				x					x				x						x			
Teacher 4	Pre-Intervention		0					0					0					0					0					0			
	Post-Intervention			x					x				x					x				x						x			
Teacher 5	Pre-Intervention		0					0					0					0					0					0			
	Post-Intervention			x					x				x					x				x						x			

4.5 Looking at the themes from a CHAT perspective

CHAT is useful for understanding the tensions between and among activity systems (Rogoff, 1990; De Beer and Mentz, 2017). In the two activity systems in Figure 4.7 (the SLP on the left, and transfer in the classroom on the right), one can clearly see that the two objects of the activity systems are not aligned. The object during the SLP was to address the technology design process as a vehicle for epistemological border crossing. Unfortunately, the object that materialized in some of the classrooms (with exceptions- as indicated in Theme 4) were the traditional 'chalk and talk' approaches. Such 'conflict' between the objects for interdependent activity systems are referred to as the 'contradiction of control' (McNeil, 2013; Mentz and De Beer, 2017). This might hinder Technology teachers from implementing professional learning in their technology classrooms.

In Figure 4.7 (on the following page), the triangle on the left represents the activity system of the SLP. Senior phase Technology teachers are the subjects and the object is epistemological border crossing where teachers infuse Indigenous Knowledge into the technology design process. Tools include indigenous knowledge, cooperative learning and practical hands-on activities (e.g., building bridges). These are tools that foster achievement of the object within the community or group the Technology teachers are a part of, which is the short course intervention community in this case. The division of labour refers to how tasks and responsibilities are defined and shared among participants engaging in the activities. In this case, facilitators were responsible for modelling the design process, engaging in cooperative learning, problem based learning strategies, and reflection during the short course to develop pedagogical content knowledge, encourage epistemological border crossing and influence integration of IK in technology classrooms. Technology teachers were responsible for learning during the course and applying strategies and knowledge in their classrooms. The activity system was governed by the rules of the CAPS Curriculum, steps of the design process and elements of cooperative learning and problem-based learning, as well as self-directed learning principles. The triangle on the right represents the activity system in senior phase post-intervention technology classrooms. At the beginning of the short learning programme, the Technology teachers (subjects) indicated that they did not know how to infuse Indigenous Knowledge into their classrooms. They indicated that very little of the application design process is taking place in their classroom hence they resort to 'chalk-and-talk' approaches, are responsible for manipulating tools in order to deliver the Curriculum to learners and prepare them to pass assessments.

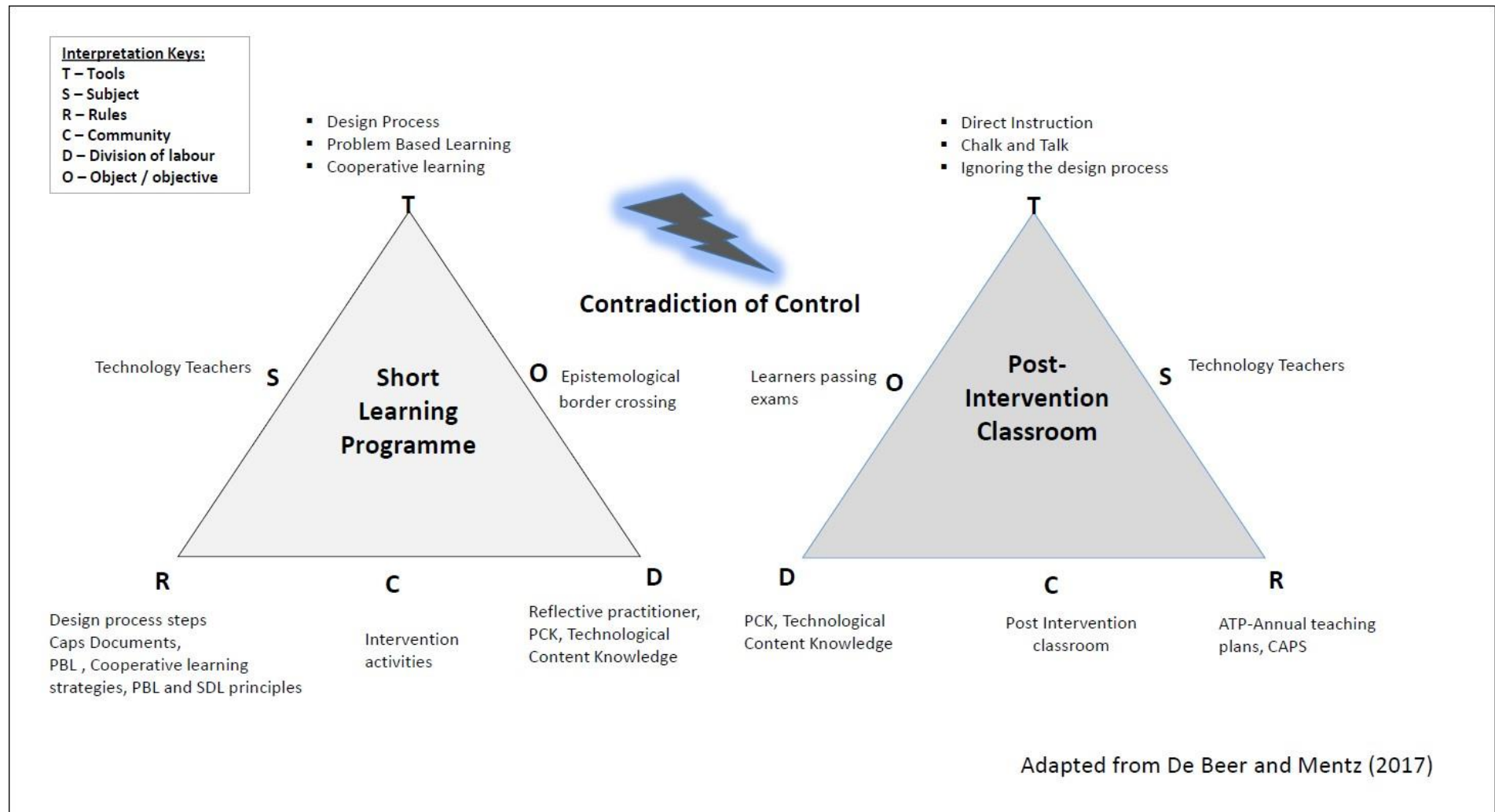


Figure 4.7: Interpreting the Qualitative Findings of the 2nd Intervention Cycle using Cultural Historical Activity Theory (CHAT)

Only two portfolios were received when this thesis was written, and the two portfolios were very different. One portfolio provided good evidence of transfer of knowledge to the classroom, whereas the other portfolio indicated that the teacher did not change his pedagogy whatsoever after the SLP. This is referred to as the “wash-out effect” in the literature.

Technology teachers are operating in both activity systems that conflict with each other. The activity system on the left occurred within the structured intervention environment and the system on the left represents the reality of the post-intervention technology classroom. The CAPS document and assessment are rules in both systems that influence other elements of the activity system. However, the CAPS Curriculum encourages use of the design process and integration of IK, but they do so without providing necessary support to ensure the implementation of appropriate strategies and knowledge in the technology classroom. The role of Technology teachers in creating a technically literate citizenry conflicts with the school structure seeking to control learners. The design process has potential to meet the DBE Technology Education goals, however the outcome is not as predictable as chalk and talk methods that Technology teachers are more comfortable with. McNeil (2013) defines the conflict between educational goals and social goals as a contradiction of control.

Technology Education is a vital component of South Africa’s social, cultural and educational transformation. Findings in this study offer insights into the challenges faced by senior phase Technology teachers regarding implementing professional development knowledge and skills into their classrooms. The results demonstrate that in technology classrooms, teachers face curricular demands that often erode the knowledge they gained in the professional development course. Based on the findings of this study, it is recommended that professional development includes continuous longitudinal support for teachers. Follow-up visits and structured support may ensure sustainability.

It is imperative that Technology teachers receive specific training in the subject area to foster PCK and effective integration of IK into technology classrooms. The lack of appropriate training disadvantages teachers as they resort to ineffective chalk and talk methods to teach a Curriculum that they do not understand.

The CAPS Curriculum places explicit pressure on teachers to meet Curriculum benchmarks and prepare learners to pass assessments. Systemic challenges in preparation and reflection time put pressure on teachers to focus on systemic issues, and also put more pressure on teachers to focus solely on preparing learners to pass their exams, rather than cooperating in the theory and practice required by the subject Technology.

4.6 Summary of Chapter Four

Three intervention cycles were progressively implemented, pertaining to a short-learning programme delivered to senior phase Technology teachers, as part of their continuous professional development, on the infusion of Indigenous Knowledge into Technology Education. The qualitative findings, pertaining to the three intervention cycles of this qualitative case study were reported and discussed.

Table 4.8 (on the following page), indicates how all of the research sub-questions (identified in Chapter 1) were successfully answered by the intervention cycle findings of this qualitative case study. By finding answers to all six my research sub-questions, all six my research sub-aims were also successfully attained. In the final chapter of my research report, that follows, the combined findings of all three intervention cycles will be used, together with findings from my literature review, in order to develop short learning programme design principles for the infusion of Indigenous Knowledge into Technology Education, which will promote both transfer of knowledge in the classroom, and self-directed learning.

Table 4.8: Research Sub-Questions Successfully Answered by the Qualitative Findings, thereby successfully attaining the Research Sub-Aims

Research Sub-Questions	Answered by the Qualitative Findings	Successful Attainment of Research Sub-Aims
1. How can Indigenous technologies be integrated and used in Higher Education as part of a short learning programme for the continuous professional development of senior phase Technology teachers?	Findings from all three Intervention Cycles In all three intervention cycles, indigenous technologies were successfully integrated and used in Higher Education as part of a short learning programme for the continuous professional development of senior phase Technology teachers.	1. To integrate and use Indigenous technologies in Higher Education as part of a short learning programme for the continuous professional development of senior phase Technology teachers
2. How can collaborative design and construction of indigenous bridge artefacts be optimally utilized to support the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education which simultaneously promote knowledge transfer and self-directed learning?	Findings from all three Intervention Cycles In all the three intervention cycles, participants were able to collaboratively share their reflections, views and thoughts regarding their participation in the intervention cycles and on the steps of problem-based learning during the design process of constructing a bridge artefact using Indigenous Knowledge and skills. The crux of this qualitative case study involved the design and make of an indigenous bridge artifact to solve the community based problem.	2. To explore how collaborative design and construction of indigenous bridge artefacts could be optimally utilised to support the development of future short learning programmes on the infusion of Indigenous Knowledge into Technology Education which simultaneously promote knowledge transfer and self-directed learning.
3. What are the attitudes of senior phase Technology teachers towards the integration and use of indigenous technologies into Technology Education?	Findings from the 1st Intervention Cycle - Technology teachers reported positive experiences of engaging with problem-based learning during the intervention - Teachers reported that the conceptualization stage stimulates creativity and creative thinking skills - Technology and Indigenous Knowledge are integrated parts of humanity and culture, and show learners the relevance of Technology in our everyday lives Findings from the 3rd Intervention Cycle Technology teachers' attitudes and viewpoints on the inherent nature of Indigenous Knowledge are: - Indigenous Knowledge is inherent culturally accumulated knowledge, transferred from one generation to the next - Indigenous Knowledge is an intrinsic component of learning - Indigenous Knowledge is inherent knowledge that is irreplaceable and non-substitutable - The integration of African indigenous technological perspectives with Western technological perspectives for the teaching and learning of Technology Education	3. To explore the attitudes of senior phase Technology teachers towards the integration and use of indigenous technologies into Technology Education.

4. What are the professional development needs of senior phase Technology teachers?	Findings from the 2nd Intervention Cycle Participating teachers indicated the following: ▪ Need for continuous in-service teacher professional development ▪ Need for continuous PCK development ▪ Need for structured support ▪ Need to transfer knowledge to classrooms Findings from the 3rd Intervention Cycle Participants indicated the following professional developmental needs in response to the qualitative questionnaire (Table 4.6): ▪ Need for appropriate resources ▪ Need for continuous development and structured support, e.g. by means of short learning programmes and workshops, with regard to time management, facilitation of processes, and relevant methodologies and strategies for the teaching and learning of Technology Education. Findings from the 1st and 3rd Intervention Cycles Participants indicated that their participation in the short-learning programme contributed towards their professional development and pedagogical practices.	4. To investigate the professional development needs of senior phase Technology teachers.
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Research Sub-Questions	Answered by the Qualitative Findings	Successful Attainment of Research Sub-Aims
5. What challenges do they face when applying the newly acquired knowledge and skills in their classrooms?	Findings from the 2nd Intervention Cycle The findings illustrate that Technology teachers face challenges to transfer knowledge, gained during the short learning programme, to their classrooms. Findings from the 3rd Intervention Cycle (Responses from the qualitative questionnaire reported in Tables 4.5 and 4.6) Participants identified the following challenges when applying the newly acquired knowledge and skills in their classrooms: ▪ Lack in available resources ▪ Lack of specialised classrooms/laboratories/facilities for Technology Education ▪ Poor parental involvement ▪ Safety issues ▪ Lack of Internet connectivity, and ▪ Language barriers, where the language of instruction differs from the home language of teachers and learners ▪ Lack of sufficient in-service training ▪ Overcrowded classrooms ▪ Problems with time management and allocation ▪ Problems resulting from cultural diversity and racism	5. To identify the challenges that senior phase Technology teachers face when applying the newly acquired knowledge and skills in their classrooms.
6. Do teachers apply the steps of Problem-Based Learning (PBL) in the design process, while acquiring Indigenous Knowledge and skills?	Findings from both the 1st and the 3rd Intervention Cycles Evidence found that Teachers applied the following PBL Steps in the Design Process and construction of a bridge artefact, while acquiring Indigenous Knowledge and skills: ▪ Conceptualise ▪ Discuss the problem context ▪ Identify knowledge and needs ▪ Formulate learning objectives ▪ Investigate ▪ Design and develop ▪ Assess	6. To investigate whether or not teachers apply the steps of Problem-Based Learning (PBL) in the design process, while acquiring Indigenous Knowledge and skills.
7. Do Technology teachers develop SDL abilities, while acquiring Indigenous Knowledge and skills?	Findings from the 3rd Intervention Cycle Evidence found for the development (or at least awareness) of the following core SDL abilities amongst Technology teachers: ▪ Taking initiative, with or without the help of others ▪ Diagnosing learning needs ▪ Formulating learning goals ▪ Identifying human and material resources for learning ▪ Choosing and implementing appropriate learning strategies ▪ Evaluating learning outcomes	7. To explore whether or not Technology teachers develop SDL abilities, while acquiring Indigenous Knowledge and skills.

Chapter 5

**Conclusion: Design principles recommended for
future short-learning programmes infusing
Indigenous Knowledge into Technology Education**

Mong-gae, tswaya! Mong-gae sala!

Molelo o se time

(Home dweller, depart! Home dweller remain!

Do not let the fire die down!)

Chapter 5

Conclusion: Design principles recommended for future short-learning programmes infusing Indigenous Knowledge into Technology Education

5.1 Introduction

In this chapter, I firstly provide short summaries of the preceding four chapters. At the end of Chapter 4, I drew on the findings of my qualitative case study to answer all the research sub-questions identified in Chapter 1. By answering my research sub-questions, I attained all my research sub-aims, which were also identified in the first chapter. In this chapter, I wrap-up and conclude my study by answering the main research question of my investigation, i.e., *What short learning programme design principles can be developed, based upon the qualitative findings of this investigation, for the infusion of Indigenous Knowledge into Technology Education, promoting both transfer in the classroom, and self-directed learning?* Accordingly, in this final chapter I use the findings obtained from my literature review (Chapter 2), as well as the qualitative findings derived from the three intervention cycles of my qualitative case study, to distil a set of design principles for future short learning programmes intended to infuse Indigenous Knowledge into Technology Education, promoting both transfer in the classroom, and self-directed learning.

5.2. Summary of the preceding four chapters

This section provides short summaries of the preceding four chapters of this research report.

5.2.1 Chapter 1 - Introduction

Chapter 1 explains the background, orientation and problem statement underlying this qualitative case study. The difficulties that are actually preventing the incorporation of indigenous expertise into South African schools' Senior Phase Curriculum are discussed. One of the problems is that the CAPS text is prescriptive, which makes it impossible for students to be innovative. I noted that there is no common conceptualization of the design process, and inconsistency in the application of the CAPS document. The chapter provides a short overview

of the worldviews from which these investigations were conceived, and also explain the conceptual research framework used for this case study. The research design and methodology that were followed in this investigation were motivated, and the chapter concludes with preliminary ethical considerations, while the chapter is wrapped up with a short overview of the chapter divisions that were used for the structuring of this research report.

5.2.2 Chapter 2 – Literature Review

Chapter 2 constitutes the Literature Review of my qualitative case study. The chapter opens with an exposition of the ontological looking glass that I used during my investigation, i.e. Ubuntu – The African philosophy of Life and Education. Then Socio- Cultural Constructivism is discussed as the higher order theoretical construct of my study. Furthermore, a distinction is made between various lower order constructs, which together, constitute the conceptual framework of my research. These include: Cultural Responsive Theory, the continuous professional development of Technology teachers, the reformation and decolonization of the school Curriculum, the origins, core content areas and objectives of Technology Education in South Africa, self-directed learning, and problem-based learning. Next, Indigenous Knowledge Systems and Indigenous Technologies were explored, followed by a discussion on the andragogic and pedagogical infusion of Indigenous Knowledge into Senior Phase Technology Education. Cognizance was taken of two existing frameworks for the infusion of Indigenous Knowledge into Technology Education, i.e. (i) Gumbo's (2018) adaptation of Seemann's (2000) Technacy Framework for Technology Education, and (ii) the Cultural Responsive Teaching Theory Framework, first proposed by King, Artiles and Kozleski (2009), and later adapted by Gumbo (2018). The chapter furthermore identified various barriers and challenges that still restrict the effective infusion of Indigenous Knowledge into Technology Education, also identified possible solutions from the literature to overcome these barriers and challenges.

5.2.3 Chapter 3 – Design Based Research

Chapter 3, designates how Design Based Research, consisting of three intervention cycles pertaining to a short-learning programme, delivered to senior phase Technology teachers on the infusion of Indigenous Knowledge into Technology Education, was used to generate the qualitative case study. From these progressive intervention cycles, design principles were distilled (see Table: 5.1 below) for the development of related short learning programmes in the future. The chapter further explains how the two research components of my qualitative case study were anchored within the *Socio-cultural Constructivist* and *Interpretivist* research

paradigms. In this chapter I further described and motivated the choice of my research design and methodology, and provided a comprehensive account of the sampling technique and selection criteria that I followed, the nature, size and demographic information of my research sample, my ethical considerations, as well as the funding support received for this project. The chapter went on to explain the various qualitative data collection approaches I used to produce qualitative data and, as a result, how I came up with an optimized hermetic unit for my qualitative data review. Chapter 3 ends with a discussion of the data analysis strategies and procedures that I followed, in order to conduct my qualitative data analysis on the integrated dataset.

In this chapter I explained how the two research components of my qualitative case study are anchored within the Constructivist and Interpretivist research paradigms. Next, the qualitative case study research design and methods of data collection were discussed. The chapter then continued to provide a comprehensive outline of the three intervention cycles that I implemented as part of the Designed-Based Research approach that I followed. The chapter furthermore provided the necessary information with regard to the research sample, and the demographical information of participants. The chapter also explained the techniques that I used in order to prepare the various sets of qualitative data, and also how these sets of qualitative data were combined into a single integrated qualitative dataset, and consequently, the chapter goes on to explain the steps I took and procedures I followed, in order to perform a constant comparative content analysis on my combined qualitative dataset.

5.2.4 Chapter 4 - Data Analysis, Presentation and Interpretation of Results

Chapter 4 focused on the analysis of the generated data from three intervention cycles. These cycles were progressively implemented, pertaining to a short-learning programme delivered to senior phase Technology teachers, as part of their continuous professional development, on the infusion of Indigenous Knowledge into Technology Education. The qualitative findings pertaining to the three intervention cycles of this qualitative case study were reported and discussed.

Table 4.7 (in chapter 4), indicates how all of the research sub-questions (identified in Chapter 1) were successfully answered by the intervention cycle findings of this qualitative case study. In this chapter, I further indicated how by finding answers to all six of my research sub-questions, my research sub-aims were also successfully attained. Chapter 5 of my research report, that follows, the combined findings of all three intervention cycles will be used, together with findings

from my literature review, in order to develop short learning programme design principles for the infusion of Indigenous Knowledge into Technology Education, which will promote both transfer of knowledge in the classroom, and self-directed learning.

5.3 Design principles for educational interventions on the epistemological border-crossing between Indigenous Knowledge systems, and Technology Education

In Table 5.1, I show the distilled design principles, from three cycles of short learning programmes.

Table 5.1: Short learning programme design principles, distilled from the findings of this investigation, for the infusion of Indigenous Knowledge into Technology Education, promoting both transfer in the classroom, and self-directed learning.

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
Chapter 1, Section 1.1, Figure 1.1.	One of the four guiding principles of African Indigenous Education, identified by Kisanji (1999), on which the success of inclusive education systems essentially depends.	<i>Design Principle 1</i> <i>The content of Technology Education should also be drawn from the physical or natural and social environments, which are intricately tied to the religious / spiritual life of the people. By linking technology content to the cultural background of the learners, the Curriculum will be seen as much more relevant.</i>
Chapter 1, Section 1.2.3 Chapter 1, Section 1.4.4	According to Ankiewicz, (2020,) it is necessary to view indigenous technology knowledge systems (ITKS) and Western technology knowledge systems (WTKS) as both serving a complementary role rather than as competing epistemological and ontological pragmatism within the Technology Education Curriculum Gumbo (2015, p. 70) shares the same vision to harness both Western and indigenous technological perspectives for culturally responsive Technology Education, characterised by: (i) the development of “open-minded” learners who can responsibly apply relevant technologies in particular local contexts; (ii) technological content knowledge that embraces values, designs, materials and applications with the aim to enrich people’s lives; (iii) learning support materials that incorporate textbooks, relevant resources, and “techno-labs” for the understanding and manufacturing of both Western and indigenous technological artefacts; (iv) the use of pedagogical approaches that are “invitational” to all learners, where they actively engage with community members and the elders regarding the design and development of products; and (v)	<i>Design Principle 2</i> <i>All knowledge, attitudes, and skills, embodied in the short learning programme should be based on cultural transmission, knowledge creation and transformation. Such short learning programmes should look at the ontology and epistemology of both knowledge systems, and highlight the similarities and differences between the knowledge systems.</i>

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
	the use of “context sensitive” assessments that assist learners to be skillful and professional in their field of study	
Chapter 1, Section 1.4.1 Chapter 2, Section 2.3.1 Chapter 2, Section 2.3.2.1 Chapter 2, Section 2.4.2.2	According to Szu-Yin and Shernaz (2014), culturally responsive teachers should be able to reflect on their own teaching practices, and should have the knowledge and skills to employ different culturally responsive methodologies, in order to become responsive to the diverse needs of learners in their inclusive classrooms. Culturally responsive teaching also demands from teachers to re-organize their classrooms in order to become accommodative towards the diverse cultural and linguistic needs of learners, and to align their classroom contexts with the contexts of their communities (Mahlangu & Mafuwane, 2015; Szu-Yin & Shernaz, 2014) The implementation and utilisation of Indigenous Knowledge for the professional andragogic development of teachers hold the potential to transform Technology teachers into culturally responsive educators, with the necessary pedagogical knowledge and skills to serve the rich diversity of learners within their inclusive classrooms effectively (Ankiewicz, 2015, 2020). For Hutchison (2006), the creation of knowledge happens within a “cultural vessel”, and nature, by its character, is the arbitrator of such creation. Therefore, it is important for Technology teachers to acknowledge the diverse cultural backgrounds of their students, in order to adequately infuse Indigenous Knowledge in their classrooms. Similarly, Hutchinson (2006, p. 308) argues that: “<i>teachers of diverse student backgrounds therefore need to be sensitive to their students’ backgrounds and what they bring to the classroom to ‘fill-in- the blank’</i>”. Within multicultural classrooms, students bring a rich cultural diversity with them to the class, which can be tapped into and contextualised for the purpose of infusing Indigenous Knowledge in Technology Education. It is within this context that a de-colonial agenda could be set in order to achieve epistemological border crossing between the western	Design Principle 3 <i>Education content should be culturally responsive to the participants. By so doing, education stake holders could relate to the content and be able to intervene in assisting in the attaining the epistemological border crossing in technology learning experiences.</i>

	knowledge systems and indigenous knowledge. I furthermore concur with Pohawpatchoko (2018, p. 2) that “<i>the inclusion of culture provides a more holistic understanding of the Indigenous experience</i>. By taking the cultural diversity of students into account during the infusion of Indigenous Knowledge in Technology Education, lays fertile ground for epistemological pluralism, while multiple ways of learning and knowing are recognized (Huckin, Andrus, & Lemon, 2012; Piaget, 1970; Pohawpatchoko, 2018).	
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Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
Chapter 2, section 2.4.2.1 Chapter 2, Section 2.4.2.2	Literature postulate quite a number of frameworks ideal for infusing Indigenous Knowledge in Technology Education. I especially took cognisance of two existing frameworks, i.e. (i) Gumbo's (2018) adaptation of Seemann's (2000) Technacy Framework for Technology Education, and (ii) the Cultural Responsive Teaching Theory Framework, first proposed by King, Artiles and Kozleski (2009), and later adapted by Gumbo (2018) .	<i>Design Principle 4</i> <i>Consider adapting existing frameworks for the infusion of Indigenous Knowledge into Technology Education.</i>
Chapter 2, Section 2.4.4.2	In the African revival era, educators need to reflect on and use indigenous cultural practices that can enhance learning, as well as project African identity (Owusu-Mensah & Poku 2015). To include Indigenous Knowledge in the classroom, it is possible to recognize the social identities of such learners, to turn to learn into a positive experience and to change the attitude of learners towards science (de Beer & Whitlock, 2009 from (Cronje et al., 2015). With competent teachers, then schools would be able to offer a conducive environment for their learners to relate in a more diverse and collaborative atmosphere and thus promote social cohesion, (Aydin et al., 2017)	<i>Design Principle 5</i> <i>Acknowledge and empower participants to accommodate social identities of the learners and societies that they serve</i>
Chapter 2, Section 2.4.4.4	For de Beer & Petersen one added benefit for including IKS in the classroom is that it can provide assistance in demystify IKS and reduce IKS marginalization (de Beer & Petersen, 2016)	<i>Design Principle 6</i>

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
		<i>Demystify Indigenous Knowledge in Technology Education</i>
Chapter 2, Section 2.4.4.5	In most South African schools, technology learners cannot afford to bring materials from home to use for their class project, (Amato, 2015). Both pre-service and in-service education programs emphasize teachers' agencies and shoestring approaches (improvising cheap alternatives), (de Villiers et al., 2016).	Design Principle 7 <i>Capacitate participants to be able to facilitate Technology Education in the environment where there is even limited resources.</i>
Chapter 2, Section 2.4.4.6 Chapter 4, Section 4.4.2.1	According to Ankiewicz, (2020,) it is necessary to view indigenous technology knowledge systems (ITKS) and Western technology knowledge systems (WTKS) as both serving a complementary role rather than as competing epistemological and ontological pragmatism within the Technology Education Curriculum. The participating teachers agreed that Indigenous Knowledge is inherent knowledge that is important, for it is irreplaceable. Participant 4 elaborated that: <i>"...Indigenous Knowledge is irreplaceable, we cannot substitute it, so all we can do is to work with it... and built on it... and never throw it away, because we will be throwing away important knowledge".</i> Furthermore, participating teachers shared their eagerness and intention to combine African indigenous technical perspectives with Western technological perspectives for senior phase Technology Education teaching and learning. Participant 4 argued that: <i>"...our setup now is Eurocentric. It is nice to be in that setup but, but we should not forget where we came from, because there were ways of dealing with technological aspects in our old ways... where we came from.... yes, it might be nice in the 21st Century, but not everything here is better than where we came from. So, therefore... given our background... how we used to do things in the past... we can bring that... and see how best we can</i>	Design Principle 8 <i>African indigenous technological perspectives should be integrated and used in combination with Western technological perspectives for the teaching and learning of Technology Education to embrace epistemological border crossing. This means that teachers should be supported during SLPs, to develop nuanced understandings of the tenets of both Technology and indigenous knowledge, as well as pedagogies to support such border-crossing in the classroom.</i>

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
	<i>match the two... [the] old days methods and Eurocentric methods... to make things work for us".</i>	
11Chapter 2, Section 2.4.4.6	"Another enabler is to link theory and practice in Technology Education classrooms", (Mapotse, 2014, p. 138)	Design Principle 9 <i>Capacitate participants to be able to employ the three task types in senior phase technology in order to ensure that theory is linked to practice in the technology classroom.</i>
Chapter 4, Section 4.2.1	For Participant 1, conceptualisation stage: <i>"...stimulates creativity and creative thinking skills".</i>	Design Principle 10 <i>Designers of SLP should cultivate positive experiences in participants when employing alternative teaching approaches such as Problem-Based learning and Cooperative learning for Technology Education</i>
Chapter 4, Section 4.2.2	- Participants conceptualised Technology and Indigenous Knowledge as integrated parts of humanity and culture. In the words of Participant 1: <i>"The infusion of humanity and culture in teaching and learning of technology... it's so mind blowing.</i> - Participant 5 furthermore remarked: <i>"We can learn from it and the way people in the past used it to satisfy their needs".</i>	Design Principle 11 <i>Indigenous Knowledge should be integrated with parts of humanity and culture. Technology teachers should be able to link classroom activities with their learners lived experiences.</i>
Chapter 4, Section 4.3.3	Lave and Wegner (1991) define a community of practice as a group of people with common interests coming together to share knowledge and improve their practice. During the SLP, teachers commented on the lack of connection, and emphasized the need for support, in order to apply the professional development training in their classrooms. Participant 2 stated: <i>"I sometimes feel isolated in my classroom, as I do not have other teachers who can mentor me. Sometimes you just need a colleague who can critique your lessons".</i>	Design Principle 12 <i>Provide fertile ground for establishment of communities of practice that would provide for structured support practice for Senior Phase Technology teachers. For example, the SLPs could be structured around the principles of the Japanese Lesson approach.</i>

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
Chapter 4, Section 4.4.2.3	Participant 2 wrote: <i>"Learners must be able to identify a problem, either in a classroom situation, on the school premises or either in a community... by getting learners engaged into identifying a problem, they interact constructively and... [it] ...promotes group work".</i> Participants indicated that learners need to cooperatively gather sufficient information on how to solve the problem using Indigenous Knowledge and Skills. Participant 1 remarked: <i>".... gathering as much as possible knowledge to resolve the problem that exist in cultural contexts".</i> Participants also indicated that they understood that learners need to identify the problem, then cooperatively find a solution based on what is needed to address the problem, while taking environmental and social factors into consideration. For example, Participant 2 commented: <i>"In the process of problem-based learning, learners need to identify the problem and also come up with a solution. The solution must be based on knowledge (what learners already know) and how to apply it with consideration... [to be of] ...help, and not... harm[full to the environment]"</i>.	Design Principle 13 <i>Encourage the presentation of ill-structured problems to learners during PBL, in order to create context, and to enhance cooperative learning in solving the problem. The SLPs should therefore utilize problem-based and cooperative learning as foundation, as this is aligned to the Vygotskyan social constructivist view on learning.</i>
Chapter 4, Section 4.4.2.2	According to Participant 1, the pedagogical use of Indigenous Knowledge provides opportunity for more in-depth teaching and learning in Technology Education: <i>"It is important because indigenous is what we learnt at home, and [when] we come to apply it in school, we go deeper... Ons delf net dieper in dit, nie net oppervlakkig nie [Translates from Afrikaans as: We delve only deeper into it, not only superficially].</i>	Design Principle 14 <i>Learning activities should embed indigenous technologies within daily professional practice and discourse.</i>
Chapter 4, Section 4.4.2.2	Indigenous Knowledge is cultural knowledge accumulated and transferred from one generation to the next. This provides an alternative means to developing practical solutions for learning	Design Principle 15

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
	problems that are contextually and culturally relevant and applicable for local communities of people (Gumbo, 2015). Participant 2 commented: <i>"I believe that Indigenous Knowledge has to do with how things were done. In the olden days, people started seeing that there were certain problems and they needed to identify what... [to] do".</i> While Participant 5 accentuated that learning through problem-solving occurs through collaborative group efforts: <i>"We engage in problem-solving by using cooperative learning skills".</i> And through social interaction, draws knowledge and skills from the ancestral memories and wisdom of their people: <i>"We engaged the elderly people to share with us ... [their] methods and knowledge".</i> Which resonates well with Gumbo's (2015, p.70) recommendation that: "indigenous teachers should mentor their peers, and they need to interact with the community to gain wisdom from the elders".	<i>Encourage and facilitate collaboration between participants, using discourse, inquiry-based activities, and public practice of teaching, e.g. invite the showcasing of local technologies and their values.</i>
Chapter 4, Section 4.4.5.6	Participants 1 and 3 emphasized the value of Indigenous Knowledge in cultivating mutual understanding and communication between different cultures, and to enable learners the opportunity to learn from each other's cultures, exemplified by the following two responses received from Participants 1 and 3 respectively: <i>"As the Curriculum across the board requires that learners of different cultures... [use] ...Indigenous Knowledge as one of the concepts to introduce culture".</i> <i>"It is interesting and it will open up that communication gaps so that we will learn from different cultures".</i> While Participants 4 and 5 have expressed their enthusiasm for instilling Indigenous Knowledge in their technology teaching, as follows:	Design Principle 16 <i>Learning activities should allow participants to examine and improve existing content and the process of instruction to integrate indigenous technological knowledge.</i>

Sections in this research report from which the design Principles are derived	Supporting Literature	Distilled design principles for future short learning programmes aimed to infuse Indigenous Knowledge into Technology Education
	<i>"Exciting and jubilating, because it closes the gap from what we know to what we will learn in... [the] ...future".</i> <i>And</i> <i>"It is a brilliant idea as learners would be moving from the known to unknown".</i> For Participant 2, on the other hand, the value of infusing Indigenous Knowledge into Technology Education, is that learners gain knowledge about the manner in which past generations used to solve problems: "I believe that it is a good thing as the learners can gain new knowledge about how things were done many years ago".	
Chapter 4, Section 4.4.4	Table 4.4 shows numerous examples of core SDL abilities that Technology teachers developed during the SLP.	Design Principle 17 <i>Learning activities should promote the development of self-directed learning skills, as well as the setting of goals amongst Senior Phase Technology teachers. In the SLPs, teachers need to formulate individual learning goals, and the facilitators could then support the teachers in their learning process.</i>

These design principles are recommended for the developers and designers of future Short-Learning Programmes for the Continuous Professional Development of Technology educators with regard to the infusion of Indigenous Knowledge into Technology Education.

Table 5.1 successfully answers the main research question of my study, thereby also successfully attaining the main aim identified in Chapter 1 for this investigation. By effectively answering my main research question in this chapter, as well as by answering all the research sub-questions in Chapter 4, this study fulfilled its' intend to help address the research problem that was identified in the first chapter.

5.4. Recommendations

From the findings of the current investigation, the following departure points are recommended for possible future endeavors to improve the epistemological border crossing between Indigenous Knowledge and western world views in Technology Education.

- I recommend that CAPS and other related guiding documents should guide teachers on the infusion of indigenous knowledge.
- I recommend that the Department of Basic Education should prioritize continuous professional teacher development.
- I recommend that Indigenous Knowledge should also be included in initial teacher education (Pre-service teacher education), not only in IN-SET.
- I recommend that imminent research should steer the collaboration of the inherent ability stated in the current research concerning the infusion of Indigenous Knowledge into Technology Education, directed by the PBL steps suggested by Havenga (2019), to improve SDL skills among Technology teachers, and to further study samples using multiple investigative methods. Such impending research ingenuities should furthermore explore, through rigorous pragmatic statistical analyses techniques, the interconnected underlying forces that seems to exist between constructs of Indigenous Knowledge systems, the steps of PBL, and SDL abilities.
- I recommend that future research on the professional development of Technology teachers make use of the updated Profile of Implementation, which has six domains, one of which is problem-based learning.
- A particular recommendation stemming from this research, is that more systemic

approaches are needed when planning professional development interventions, including all stakeholders in the planning of such interventions. The SLP presented during the three cycles in this study, was developed without buy-in from stakeholders such as the Department of Basic Education, teachers themselves, school management and principals, or parents. Mentz and De Beer (2019) recommend that ‘change laboratories’ should precede professional development interventions, and that the inputs of all stakeholders could ensure better transfer of new knowledge and skills to the post-intervention classroom. These authors refer to the utilization of fourth generation CHAT (refer to Figure 5.1)

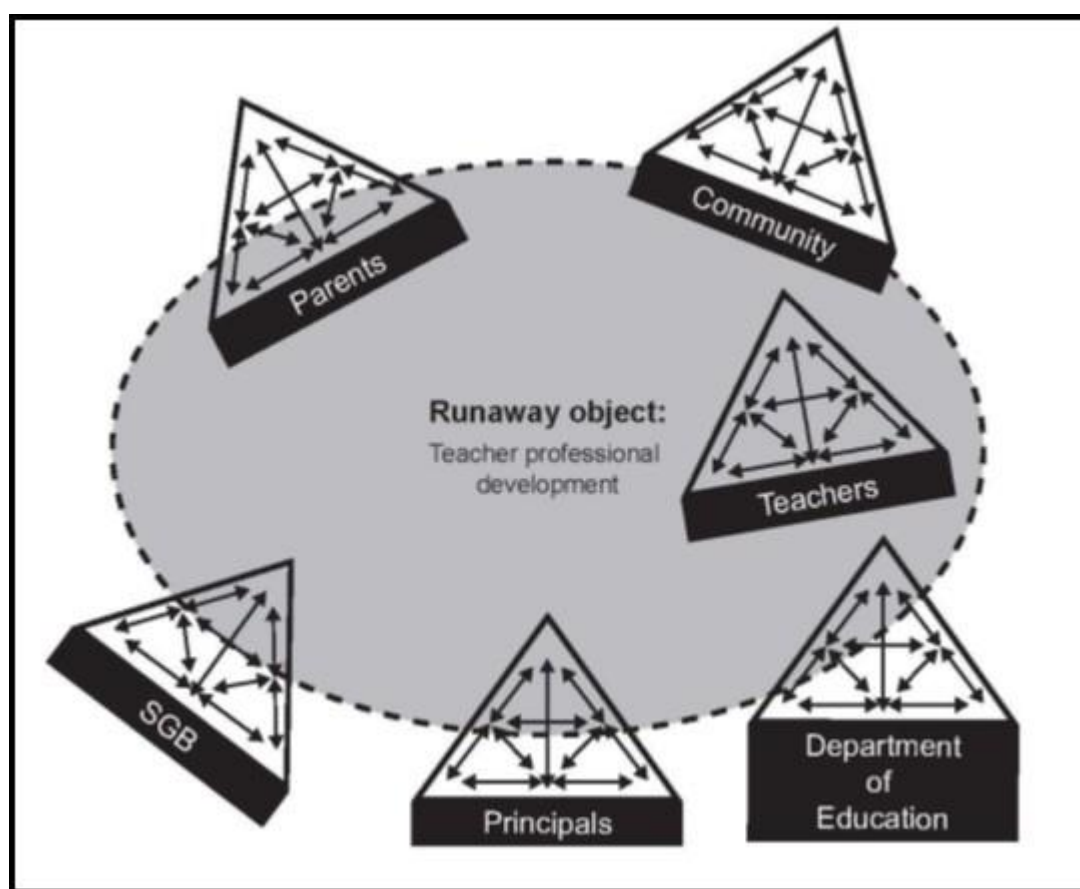


Figure 5.1: Change laboratories and fourth generation CHAT, as visualized by Mentz and De Beer (2019, p. 263).

5.5. Value contribution of my Qualitative Case Study

Through this study the following major contributions have been made:

5.5.1 An epistemological contribution

This qualitative case study has contributed to the growing body of literature within the scope of Technology Education and Indigenous Knowledge, and to efforts to facilitate the

transformation of technology teaching and learning in order to make it more representative of the cultural context of learners and to extract the richness of Indigenous Knowledge from the elderly in the communities. This study will hopefully provide more insight into epistemological border-crossing between “western” Technology, and indigenous knowledge. Balfour’s statement (2019, p. xxxvii) is probably applicable to this study, as the study attempted to “locate the text within the nascent scholarship concerning the decolonisation of the Curriculum (in fields beyond postcolonial literary studies), and positioning Indigenous Knowledge systems as a means through which Curriculum and Curriculum making, pedagogy and teaching methodologies come to be revisioned”. The other value contribution of this qualitative case study is made with regard to epistemology is within the transformation of technology teaching and learning in order to make it more representative of the cultural context of learners and to extract the richness of indigenous knowledge from the elderly in the communities.

5.5.2 Research contribution

This study was a direct response to Gumbo’s call, for researchers to explore the integration and use of indigenous technologies for the professional development of Technology teachers in South Africa, and furthermore to investigate the attitudes of Technology teachers towards indigenous technologies. Cultural-historical Activity Theory is seldom used in Technology Education research, and the use of CHAT as research lens will enrich research methodology in the field.

5.5.3 A practical contribution

Design principles were distilled in this research, for the future development of Short-Learning Programmes for the Continuous Professional Development of Technology educators, specifically with regard to the infusion of Indigenous Knowledge in Technology Education. The study provided a contribution toward knowledge of the infusion of Indigenous Knowledge in the senior phase Technology Education Curriculum within the context of South African schools which adds to the agenda that Education should be more inclusive. I further believe that this study also added to the voices that call for democratization of knowledge or knowledge ecologies supporting the notion epistemological decolonization. This study further provides in-depth contextual view of a short learning programme for the infusion of Indigenous Knowledge in Technology Education Curriculum. The value of this study is that it might, at grassroots level, change the attitude and perception of Technology teachers regarding the infusion of Indigenous Knowledge in the Technology Education. I make this assumption based on similar

intervention studies in Life Sciences (Mothwa, 2011; Cronje, 2015). By participating in the SLP's, the teacher have benefited by getting an exceptional appreciation of Technology as a subject and how to infuse Indigenous Knowledge in their classrooms, in order to the benefit of their learners. The study further exposed conditions that are necessary to support teachers in the infusion of Indigenous Knowledge in the Technology Curriculum.

5.6 Limitations of my Qualitative Case Study

This study was only a Qualitative Case Study of which the findings cannot be generalised for the wider South African populace. The other limitation to this study was within the application of the DBR which required constant physical interaction, however due to the Covid 19 restrictions certain constraints were experienced. It is for this reason that I recommend that future research could focus on the quantitative component in this regard. Furthermore, I am of a very strong opinion that future research should include a larger diversity of Indigenous Knowledge systems representative of the rich diversity of people in South Africa.

5.7 Summary of the chapter

Chapter 5 is a concluding chapter for this qualitative case study. The conclusions are drawn from what is contained in each of the chapters while accentuating some pivotal matters regarding this investigation. This chapter further has elucidated some challenges of this study which can further be interrogated by Technology Education scholars regarding the infusion of indigenous knowledge. I conclude this chapter by putting up a final word in order to reflect on the transformative educational journey this case study has provided me with as an emerging scholar in the field.

5.8 The final word

This study has been quite an exciting educational experience for me, most importantly because I was engaged with infusing ingenious knowledge in Technology Education which is the matter that has the potential to be seen as not being significant, particularly during the era of the fourth industrial revolution. In this era, Indigenous Knowledge might be pushed to the periphery with the potential to rob the populace of the educational richness and diversity Indigenous Knowledge provides in Technology Education. With that in mind, I posit that both western perspectives and Indigenous Knowledge are mutually important and both are

deserving of respect and recognition within the Technology Education arena. More so, because I noticed that there was little literature explicitly regarding Indigenous expertise in Technology Education, since most of the findings were based on a Natural Science narrative. Throughout this research journey, I have become aware of the interrelated indigenous awareness related to human lives in Technology Education.

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List of References

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Addenda

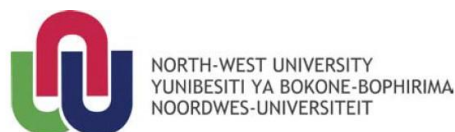
Addendum A: Ethical Clearance

Addendum B: Informed Consent Form

Addendum C: Questionnaires

Addendum D: Research Publications

Addendum A: Ethical Clearance



NORTH-WEST UNIVERSITY
YUNIBESITHI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Private Bag X6001, Potchefstroom,
South Africa, 2520

Tel: (018) 299-4900

Faks: (018) 299-4910

Web: <http://www.nwu.ac.za>

Institutional Research Ethics Regulatory Committee

Tel: +27 18 299 4849

Email: Ethics@nwu.ac.za

2016-06-297

ETHICS APPROVAL CERTIFICATE OF STUDY

Based on approval by the **Ethics Committee of the Faculty of Education Sciences (ESREC)** at the meeting held on **23/06/2016**, the North-West University Institutional Research Ethics Regulatory Committee (NWU-IRERC) hereby **approves** your study as indicated below. This implies that the NWU-IRERC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: The affordances of indigenous knowledge for self-directed learning																
Project Head:	Prof J de Beer															
Research Team:	Prof Elsa Mentz, Prof Marthie van der Walt, Dr Neal Petersen, Dr Christo van der Westhuizen, Prof Aubrey Golightly, Ms Lounell White, Prof Marietjie Havenga, Mr Kobus Havenga															
Ethics number:	<table border="1"><tr><td>N</td><td>W</td><td>U</td><td>-</td><td>0</td><td>0</td><td>2</td><td>7</td><td>1</td><td>-</td><td>1</td><td>6</td><td>-</td><td>A</td><td>2</td></tr></table> Institution Study Number Year Status Status: S = Submission, R = Re-Submission, P = Provisional Authorisation, A = Authorisation	N	W	U	-	0	0	2	7	1	-	1	6	-	A	2
N	W	U	-	0	0	2	7	1	-	1	6	-	A	2		
Application Type: N/A																
Commencement date: 2016-06-24	Expiry date: 2018-12-24															
Risk:	<table border="1"><tr><td>N/A</td></tr></table>	N/A														
N/A																

Special conditions of the approval (if applicable):

- Translation of the informed consent document to the languages applicable to the study participants should be submitted to the ESREC (if applicable).
- Any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the ESREC. Ethics approval is required BEFORE approval can be obtained from these authorities.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The study leader (principle investigator) must report in the prescribed format to the NWU-IRERC via ESREC:
 - annually (or as otherwise requested) on the progress of the study, and upon completion of the project
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the proposal as stipulated in the application form. Would any changes to the proposal be deemed necessary during the course of the study, the study leader must apply for approval of these changes at the ESREC. Would there be deviated from the study proposal without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-IRERC via ESREC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-IRERC and ESREC retains the right to:
 - request access to any information or data at any time during the course or after completion of the study;
 - to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected,
 - it becomes apparent that any relevant information was withheld from the ESREC or that information has been false or misrepresented,
 - the required annual report and reporting of adverse events was not done timely and accurately,
 - new institutional rules, national legislation or international conventions deem it necessary.
- ESREC can be contacted for further information or any report templates via Ema.Conradie@nwu.ac.za or 018 299 4656

The IRERC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the IRERC or ESREC for any further enquiries or requests for assistance.

Yours sincerely

Prof LA
Du Plessis

Digitally signed by
Prof LA Du Plessis
Date: 2016.06.30
08:45:53 +02'00'

Prof Linda du Plessis

Chair NWU Institutional Research Ethics Regulatory Committee (IRERC)

6 April 2020

To Whom It May Concern

I hereby confirm that ethics application, as stated below, was approved by the critical readers and will be minuted at the EduREC meeting of 30 April 2020.

Ethics number: NWU-00791-18-A2

Project head: Prof JJJ de Beer

Project team: B Seleke (PhD student – 18047335)

Title: Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom

Extended period granted: 6 April 2020 – 6 April 2021

Clearance given for only one year. Extension can be requested after a year.

Risk level: Low

Should you have further enquiries in this regard, you are welcome to contact Prof Jako Olivier at 018 285 2078 or by email at Jako.Olivier@nwu.ac.za or Ms Erna Greyling at 018 299 4656 or by email at Erna.Greyling@nwu.ac.za.

Yours sincerely



Prof J Olivier
Chair Edu-REC

Addendum B: Informed Consent Form

The signed concerned letters from participants are not included here, as it contains personal information of participants. The completed consent forms are stored in a safe on the Potchefstroom Campus of the NWU for at least 10 years. Any person or institution that wishes to view them is more that welcome to contact the author for arrangements.

July 2018

Dear Technology Teacher

Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom

Welcome to the *A-Team*, and this unique professional development opportunity, that include a 16-credit short course on indigenous knowledge! We trust that you will enjoy the exciting research and professional development journey with us, and that it will be valuable in your own professional development as a teacher. Your membership of the *A-Team* holds many advantages, as will be explained later on in this letter.

You are invited to take part in our research as described underneath. It is therefore important that you read and understand the following general principles, which are applicable to our research project. After reading the information, we hope that you will positively consider participating, in which case you please need to sign the consent form.

1. FOCUS OF THE RESEARCH

This research focuses on technology teachers' the infusion of indigenous knowledge in the technology education curriculum themes. The title of the research is **Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom**

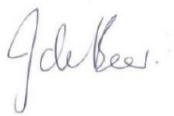
. There are no right or wrong answers or views, and we would appreciate it if you could share your thoughts with us.

2. ETHICAL GUIDELINES FOLLOWED IN OUR RESEARCH

- We received Ethical clearance from the North-West University's applicable REC (NWU-00271-16-A2). Participation in this research is completely voluntary and no pressure, however subtle, will be used for you to take part. You are more than welcome to attend the short course and interventions, even if you choose not to participate in our research.
- The research will not hold any potential risks or discomfort for you as a participant. To the contrary, we will provide you with lovely resources for your classroom, and will invest in your professional development.
- By agreeing to take part in the research, you are also giving consent that the data may be used for publication purposes. However, you are assured of confidentiality, and your name will not be used at all (pseudonyms will be used).
- If you so wish, we would like to invite you to also participate in this research after this short course and interventions. We are interested in your experiences in teaching contextualised technology in your classroom.
- You may withdraw from this research at any stage, and there will be no consequences in doing so.
- If you would be interested, we will share the outcomes of this research with all participants.
- No financial compensation will be made to participants in the study. However, you will receive resources, as well as the opportunity to enrol for selected SLP's free of charge.
- You are more than welcome to contact us, if anything is unclear to you.

Thank you very much!

Regards



JOSEF DE BEER (PROF)
(CELL: 082 923-2865)



Mr. B SELEKE
(0833948407)



CONSENT LETTER

Research project: *Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom*

Name of Researcher: Mr B SELEKE ([Office (018) 285-2085]); Prof Josef de Beer ([Office] (018) 285-2626)

I, the undersigned(full names & surname of participant) have read the preceding premises in connection with the research and have also heard the oral version thereof and I declare that I understand it.

With this declaration I give my voluntarily consent to take part in the research. I also take note of the fact that I may withdraw from this research at any point, without any consequences for me. (Please see the contract regarding the issuing of tablets). I understand that my participation in this research will mean that a personal interview will be conducted with me, and I will be asked to complete a questionnaire. If I choose to participate in the second phase of this research, I understand that the researchers will study my lesson plans.

Signature _____

Date _____

Witness signature _____

Date _____

Addendum C: Questionnaire

The questionnaires that the participants completed are not included here, as it contains personal information of participants. The completed questionnaires are stored in a safe on the Potchefstroom Campus of the NWU for at least 10 years. Any person or institution that wishes to view them is more that welcome to contact the author for arrangements.

PRE-QUESTIONNAIRE: TECHNOLOGY

Dear Teacher

Thank you for your willingness to answer a few questions. The purpose of this short questionnaire is to determine what your views are on aspects related to Technology teaching. There are no right or wrong answers. Your answers will be considered confidential.

Name/ pseudonym/ Unique code:

1. Which subject(s) and grades are you currently teaching?

Subject	YES	NO
Technology (Senior Phase, Grades 7 – 9)	1	2
FET subjects (please specify below)	1	2
Natural Sciences (Grades 7 – 9)	1	2
Mathematics Intermediate Phase (Grades 6 – 8)	1	2
Mathematics Senior Phase (Grades 7 – 9)	1	2
Other (Please specify)	1	2

Other- please specify:

2. Describe your school (e.g. is it an urban, rural or township school, and what resources are available)?

- 2.1. My school can be described as:

Urban school	Township school	Rural school
1	2	3

2.2. Availability of resources	YES	NO
Does the school have good resources (e.g. data projector, lab consumables, equipment for Technology, etc)?	1	2
Do you have a Technology workshop?	1	2
Do you have access to internet (either via computer or smart phone)?	1	2
Do you have access to a library?	1	2

3. What are your highest qualifications?
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4. How long have you been teaching Technology?
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5. How do you plan a Technology lesson?
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6. How will you contextualise (show the relevance) the teaching of Technology themes (e.g. the Technology design process/ Structure /mechanical systems and control/electrical/processing etc) to learners?
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7. Is it possible for a teacher to facilitate practical work without a Technology workshop or laboratory? Motivate your answer.
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8. How do you use ICT's (and simulation software) in your teaching?
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9. What are your views on using problem-based learning in the Technology classroom? Give an example of a lesson in which you use problem-based approaches.
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10. What are your views on using cooperative learning in the Technology classroom? Give an example of a lesson in which you use cooperative learning approaches.
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11. What are your views on including indigenous knowledge in the teaching of Technology?

12. How can a teacher include indigenous knowledge in a Technology (CAPS) lesson?

13. What are the challenges that technology teachers face in infusing indigenous knowledge senior phase technology?

14. What strategies do you think are current in place for the infusing of indigenous knowledge in senior phase technology?

15. What conditions do you propose to be ideal for the infusing of indigenous knowledge in senior phase technology in the South African School context?

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16. Which threats/ hindrances within in the current South African School system could inhibit successful infusion of indigenous knowledge in senior phase technology curriculum themes?

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17. What guidelines should serve as indicators for successful infusion of for the infusing of indigenous knowledge in senior phase technology curriculum themes?

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Thank you for completing this questionnaire!

POST QUESTIONNAIRE: TECHNOLOGY

Dear Teacher

Thank you for your willingness to answer a few questions. The purpose of this short questionnaire is to determine what your views are on teaching Technology, and on the short learning programme that you participated in. There are no right or wrong answers. Your real name will not be revealed when we report on the findings.

Name/ pseudonym/ identification code:

- How did you experience this SLP on interventions for contextualising Technology through the infusion of indigenous knowledge?

Very poor- a waste of time	It had useful aspects, and made some contribution towards my development	Good- it definitely made an impact, and helped me in my professional development	It was fantastic , and I learned a lot. I can't wait to implement what I have learned in practice.
1	2	3	4

- How would you describe contextualised Technology teaching?

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- What are the difficulties that you anticipate in implementing the teaching methods/ strategies introduced during this SLP?

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4. Did this SLP change your views on the use of cooperative learning (CL) methods in the Technology classroom? Motivate your answer.

No, not at all	Very little	Yes, it did	Absolutely! I will definitely use cooperative learning strategies more in future
1	2	3	4

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5. Did this SLP change your views on the use of problem-based learning (PBL) methods in the Technology classroom? Motivate your answer.

No, not at all	Very little	Yes, it did	Absolutely! I will definitely use PBL more in future
1	2	3	4

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6. Please provide an example of how you would use problem-based learning (PBL) to teach a topic in the Technology CAPS classroom.

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7. Please provide an example of how you would use cooperative learning (CL) strategies to teach a CAPS topic in your classroom.

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8. Did this SLP change your views on the role of reflection in one's professional development? Motivate your answer.

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9. Explain how you made use of shoestring approaches in your classroom (e.g. teaching Technology topics with every day, cheap materials) in the past. Did this SLP change your views on such shoestring approaches?

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10. Based on your experiences during this SLP, is it necessary for you to formulate any professional development goals for yourself? (E.g. did you identify any knowledge- or skill gaps that you would like to address?)

Theme/ category	No development goals- I do fine	I identified the following professional development goals:
Knowledge on CAPS themes		
Laboratory/ workshop skills (e.g. the Technology design process)		
Problem-based learning approaches		

Cooperative learning techniques		
Shoestring approaches (using inexpensive materials in PBL approaches)		
Reflection		

11. General comments

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Thank you for completing this questionnaire!



Name of the Researcher: SELEKE BENJAMIN

Title of Thesis: Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom

Pseudoname _____

Semi-Structured Interview Questions

1. Does Indigenous Knowledge get enough coverage in the senior phase Technology curriculum and what are the possibilities of including multiple cultural IKS in South African schools?
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2. To what extent does one's beliefs or cultural background influence the teaching and learning of Senior phase Technology?
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3. What are the challenges that Technology teachers face in infusing indigenous knowledge in senior phase Technology curriculum themes?
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4. What strategies are currently in place for the infusion of indigenous knowledge in senior phase Technology?
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5. What threats or systemic problems could inhibit successful infusion of indigenous knowledge in senior phase Technology?
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6. What guidelines should serve as indicators for successful infusion of indigenous knowledge in senior phase Technology?
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7. What space do other knowledge systems have in Technology education given that the current syllabus is largely Eurocentric?
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8. Which aspects/topics should be taught/ included in senior phase Technology to embrace indigenous knowledge?
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Based on responses, follow-up questions might be asked to participants.



Reflections on the application of the design process in Technology

SPL

Scaffolding teachers' professional development for the infusion of indigenous knowledge transfer in the Technology classroom

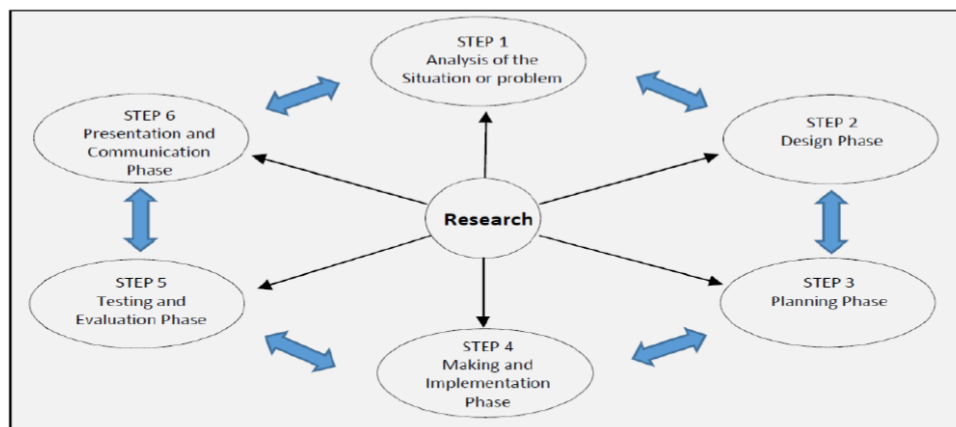
1. The Design Process/ Technological Process/ IDMEC

The design process in Technology Education hold a novel opportunity for infusing indigenous knowledge. Department of Basic Education advocate for the application of the design process in Senior Phase, which are they coiled as IDMEC, i.e. Investigate, Design, Make, Evaluate and Communicate (Department of Basic Education, 2011). As depicted in Senior Phase CAPS document the following table in 1.1. Illustrate the deign process.

- The table below indicates the main focus areas in the Technology curriculum:

1.	THE DESIGN PROCESS SKILLS (non-linear): - Investigation skills - Design skills - Making skills - Evaluation skills - Communication skills	
2.	STRUCTURES	
3.	PROCESSING OF MATERIALS	
4.	MECHANICAL SYSTEMS AND CONTROL	
5.	ELECTRICAL SYSTEMS AND CONTROL	
6.	TECHNOLOGY, SOCIETY AND THE ENVIRONMENT - Indigenous technology - Impact of technology - Bias in technology	

Technology Education is by its nature a theory-practice subject that requires skilled teachers to employ Problem based strategies (Mapotse, 2014:10). Technology teachers need to know how learners proceed towards the design process and the execution of the classroom instruction. The following is a cyclic presentation of the design process according to (Combrinck & Reitsma, 2004)



The Six Steps Cyclic Representation of the Design Process (Combrinck & Reitsma, 2004)

1.2.Problem-Based Learning in Technology Education

Problem-Based Learning is defined by Japer, Abimanyu, Arsyad and Dirawan (2014, p. 46) as a model of learning which is student orientated to stimulate a multidirectional interaction and social skills amongst students to constructively engage in finding solutions to real life challenges. Problem-Based Learning is an educational approach whereby the problem is the starting point of the learning process. It is increasingly embraced as a learner- centered approach that suppresses the role of the teacher by facilitating student involvement in every learning process (Sikoyo, 2010: 247). This learning approach is articulated as a student-centred teaching philosophy aiming at exciting students to continue to engage in lifelong learning beyond the formal educational conditions (Mcfalls, 2013: 1). The following are the PBL steps as proposed by (Havenga ,2019)

Table 1. Teachers applying knowledge and skills in a short learning programme on indigenous technology (based on research HM Havenga, 2019)

Steps	Teacher (S) apply various steps, strategies (T) to achieve the goals (O)	
1. <u>Conceptualise</u>	Understand the rationale of using IK in the Technology curriculum. Teachers reflect on their own knowledge regarding concepts, e.g. technology as a distinctive form of knowledge, artefacts, a unit of processes and technological involvement in humanity and culture	Reflection

2. <u>Discuss the problem context</u>	Obtain knowledge regarding an indigenous technological problem in cultural contexts as part of communities of practices to explore the problem context or scenario	
3. <u>Identify knowledge and needs</u>	Identify knowledge and the community needs. Some examples are: -People have to cross the river to get in the town (why) -The bridge must be accessible for people with disabilities, elderly people, and children (who) - The bridge must be high enough so that it can still be used in rainy weather (how)	
4. <u>Formulate learning objectives</u>	Identification of a particular problem in their community to address. Design and develop a bridge that should be long enough to allow people of the community to cross the river safely without walking on the riverbanks	
5. <u>Investigate</u>	Search for appropriate sources and make informed judgements. Use books and photos, ask people in the community and the elders. If available ICTs can be used to search for examples of bridges	
6. <u>Design and develop</u> e.g. the technological process applied in IK.	Design a prototype bridge for the community. Draw a freehand sketch of this idea. Determine the advantages and disadvantages, reflect, and make changes to the design. Develop a prototype of the bridge using, e.g. wood, cardboard, glue. Reflect on all activities. Test the strength of the bridge and finally submit the bridge prototype, portfolio, and/or report as deliverables	
7. <u>Assess</u>	Determine each member as well as the groups' contribution towards the problem-based task and learning gains. Determine whether development of the artefact addressed the problem of inquiry	

1.3. Reflections on the Application of the design Process in Technology Education

On the space provided below please complete the following reflection on your thoughts about the steps of the design process and problem based learning while you were engaged in your project.

1.3.1. Conceptualise

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2. Discuss the problem context

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3. Identify knowledge and needs

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4. Formulate learning objectives

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5. Investigate

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6. Design and develop e.g. the technological process applied in IK.

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7. <u>Assess</u>	Determine each member as well as the groups' contribution towards the problem-based task and learning gains. Determine whether development of the artefact addressed the problem of inquiry
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Thank you for completing the reflection.

Addendum D: Research Publications

Accredited Book Chapter

Seleke, B., Els, C.J. & De Beer, J. (2019). Utilising Indigenous Knowledge in Higher Education for the professional development of culturally responsive Technology teachers. In J. Pool & M. Fernandes-Martins (Eds). *A Scholarly Approach to Student Success in Higher Education*. Potchefstroom: Ivyline Academic Publishers. (ISBN: 978-1-990924-01-9).

Conference Papers Published in Conference Proceedings

Seleke, B., Speight Vaughn, M. & De Beer, J. (2018). Senior Phase Technology teachers' professional development and implementation needs: a case study. *Proceedings of the 9th Annual UNISA ISTE Conference on Mathematics, Science, and Technology Education, 22 to 25 October 2018, Kruger National Park*.

Seleke, B., Havenga, M. & De Beer, J. (2019). The Enhancement of self-directed learning through the engagement in problem-based learning activities during a professional development programme on Indigenous Knowledge for Technology teachers. *Proceedings of the 8th International ISES Teaching and Education Conference, 17 September 2019, Vienna, Austria*.